THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 41 MARCH, 1939 No. 3

THE USE OF THE ROENTGEN RAY IN OBSTETRICS*

PART I. ROENTGEN PELVIMETRY AND CEPHALOMETRY; TECHNIQUE OF PELVIOROENTGENOGRAPHY

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INTRODUCTION

THE increasing use of roentgenologic methods of examination in the study of the pelvis and the mechanics of labor has revealed the need for special diagnostic experience in film interpretation on the part of the roentgenologist and obstetrician. Each should be trained to appreciate the obstetrical significance of what he may visualize in the roentgenograms, particularly those factors in the pelvis and fetal head which cause the common forms of mechanical complications in labor. During the last five years, the Sloane Hospital for Women, cooperating with the Department of Radiology of the Presbyterian Hospital, has made extensive use of the roentgen ray as an aid in obstetrical diagnosis. The purpose of this paper is to present the results of the study of these cases with a review of previous publications upon this subject.[3,4,5,6,7,8,21]

A roentgenologic examination obtained at or near term gives information on the following factors concerned in labor:

(1) The presentation of the fetus, feta abnormalities, the presence of multiple pregnancy, signs of fetal death, etc.
(2) The size and shape (anatomical classification) of the maternal pelvis.
(3) The size and shape and the degree of flexion or extension of the fetal head.
(4) Fetal-pelvic relationships, i.e., the obstetrical position of the head in relation to the pelvic inlet, and the station of the head in respect to the symphysis in front or the sacrum behind.
(5) The level of the head in respect to the pelvic inlet.

Roentgenograms obtained after the onset of labor give information concerning the fetal head itself and the fetal-pelvic relationships. In certain instances indirect evidence of the efficiency of the forces of labor may be observed. Abnormalities in the lower uterine soft parts and the maternal pelvis may act as contributory causes for the following effects of labor:

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(1) The change in the degree of flexion or extension; the existing degree of moulding.
(2) The change in level of the head within the pelvis.
(3) The change in the axis of descent of the head through the pelvis.
(4) The change in head position with descent as a result of adaptation to the shape of the pelvis (Mechanism of Labor).

From a roentgenologic standpoint, the factors concerned in labor may be divided into two classes: the measurable and the immeasurable. The measurable factors consist of the classical diameters of the maternal pelvis and the fetal head, the volume capacity of any diameter, and the volume of the fetal head in terms of cubic centimeters. The other factors listed above are considered immeasurable since they refer to shape, position, or relationship of one anatomical part to another. The roentgenologist should employ a technique and a method of film interpretation which will enable him to report fully upon both the measurable and the immeasurable factors in each case. Until recently, published reports on the subject dealt chiefly with details of the technique employed to obtain measurements. Little attention has been paid to the practical application of these measurements in terms of ease or difficulty in labor. This present investigation is concerned primarily with *how* the fetal head descends through pelves of variable shapes. It was thought that this approach might show the fetal and pelvic factors which cause arrest in the occipitoposterior position and in the transverse position, and the correct mechanical principles to employ in forceps operations and other related obstetrical problems. It was found that the most satisfactory information concerning the fetal-pelvic relationships could be obtained from stereoroentgenograms. It also was evident that a method to determine pelvic and fetal head size, while studying the stereoroentgenograms, would further increase the practical value of the examination. Through modification of the method of the "phantom image," a technique has been developed which permits the study of the measurable and the immeasurable factors in all cases simultaneously.

It seems advisable to present the subject of obstetrical roentgenology in three parts, as follows:

PART I

Roentgen Pelvimetry and Cephalometry
Technique of Pelvioroentgenography

PART II

The Anatomical Variations in the Female Pelvis and their Classification According to Morphology

1. The analysis of pelvic shape
2. The classification of pelves according to shape
3. The lower pelvis
4. Frequency of occurrence of pelvic types
5. Average measurements

PART III

The Mechanism of Labor

1. The act of engagement through a curved axis of descent
2. Variations in the axis of descent within the pelvis
3. Head adaptation to pelvic shape
4. The significance of pelvic shape in the treatment of pelvic arrest
5. The shape of the outlet in operative deliveries

ROENTGEN PELVIMETRY AND CEPHALOMETRY

Most methods of roentgen pelvimetry and cephalometry are modifications of the so-called frame, or position methods, and of the parallax, or stereoscopic methods. The use of mechanical methods of correction for distance distortion is more popular than simple formulae. The pioneer work of Thoms,[27] especially in regard to the frame method, is well known. He makes use of a lead grid which, when placed in the supposed plane of the inlet, marks the films for direct measurement following a second

flash exposure. Thoms and Wilson,[28] Jarcho,[19] Jacobs,[18] Weitzner,[30] and others, have modified the technique to obtain the true conjugate diameter from the lateral view. Johnson,[20] by the use of a stereoroentgenometer, has devised a popular parallax method which reconstructs the pelvic diameters by means of the cross-thread principle of stereoscopic measurement first devised by MacKenzie Davidson.[10] Frame and stereoscopic methods, by suitable modifications, are applicable for measurement of the cephalic diameters. The fetal head is naturally more difficult to measure than the fixed diameters of the maternal pelvis. Movement of the fetus during exposure and the location of the correct end-points of each cephalic diameter represent the chief sources of error. Pelvic measurements obtained by any one of these methods or their numerous modifications are accurate within practical limits. Schumann,[25] for example, by direct measurement of the inlet diameters at operation has shown that Thoms' method of pelvimetry is accurate within 2 mm. Clifford[9] has reported favorably upon the accuracy of Johnson's method for the pelvic and fetal head diameters.

Workers interested in frame or parallax methods of measurement have avoided detailed reference to the manner in which an obstetrical prognosis may be given in terms of anticipated ease or difficulty in labor. Because of the variability of the forces concerned in labor, it is obviously difficult to determine whether or not a head is too large to be safely delivered through a small pelvis, even though the diameters of each have been accurately measured by methods of roentgen pelvimetry and cephalometry. Recently the work of Ball and Marchbanks[2] has renewed interest in the diagnostic potentialities of roentgenologic methods depending upon the measurable factors for determining the degree of difficulty in labor. Their approach to the problem represents a decided improvement as the degree of disproportion between the fetal head and the maternal pelvis can thus be expressed in simple mathematical terms. Ball,[1] not satisfied with the accuracy of the cardinal head diameters as indicators of head size, has proposed a simplified technique by which head size can be estimated in terms of volume. Hodges[17] has called this method of measurement the "ninety degree triangulation method." Ball determines the volume capacity of the anteroposterior diameter of the inlet in terms of a sphere with the same diameter. If the volume of the head exceeds by 150 cc. the volume of a sphere whose diameter is the anteroposterior diameter of the pelvic inlet, Ball considers the difference probably too great to be safely handled by the shift of volume occurring through changes in head shape with moulding. Ball has not determined as yet the limit of safety at the level of the ischial spines. He has found that a 5 per cent error in pelvic measurement and a 10 per cent error in volumetric estimation of head size may occur. When the fetal head is not fixed in the pelvic inlet, it may be displaced with change in position during exposure and thus cause an error in measurement. Ball, however, has checked the estimated head volume by measuring the fetal head after delivery and has found this error to be negligible. Hodges,[17] on the other hand, considers this source of error more seriously and has had success in decreasing head movement by the use of a specially constructed frame to fix the patient rigidly during exposure. The results of Ball's work tend to indicate that head volume is a better index of head size than the classical cephalic diameters. This method of prognosis would also seem to be the most practical one which attempts to estimate ease or difficulty in labor by means of measurements alone.

The technique of frame methods of roentgen pelvimetry and cephalometry and Ball's method of volumetric fetal head and pelvic comparison are simplified to consist of not more than two large films: a lateral and an anteroposterior view. As a result, these films are not entirely suitable for the

FIG. 1. *A.* Chart No. 542278. X-ray No. 167780. A white primipara, aged thirty-four, was delivered by easy low forceps from the right occipito-anterior position of a 3,450 gm. child after a labor of thirteen hours. Roentgenogram shows an android-anthropoid type with a narrow interspinous diameter, straight side walls, and an ample subpubic arch and fore pelvis.

Anteroposterior diameter of inlet.....12.5 cm.
Widest transverse diameter of inlet.....13.5 cm.
Interspinous diameter..... 9.5 cm.

A major degree of disporportion exists between volume of head (670 cc.) and the volume of the interspinous diameter (370 cc.). In this case the head descended through the relatively wide fore pelvis, *a*, which compensated for the narrow interspinous diameter. This illustrates the fact that one narrow diameter is not necessarily the index of pelvic capacity.

B. Chart No. 471666. X-ray No. 142186. A white primipara, aged twenty-eight, was delivered by low forceps from the left occipitotransverse to left occipito-anterior position of a 3,410 gm. child after a labor of twenty hours. Films in labor show an extreme android-anthropoid type of pelvis with converging side walls, a narrow interspinous and intertuberous diameter with a long anteroposterior diameter caused by the anthropoid shape at the inlet and a backward inclination to the sacrum. The head, well flexed and

study of the shape of the maternal pelvis or of the fetal-pelvic relationships in regard to the mechanism of labor.

The recognition of a small pelvis or the presence of any degree of disproportion has definite diagnostic value. We have noted, however, that in the large group of so-called borderline cases the results of roentgen pelvimetry and cephalometry by themselves usually fail to acquaint the obstetrician with the type and treatment of the difficulty in case of arrest of the fetal head. The study of fetal-pelvic relationships in conjunction with the known results of labor has shown that easy labors have occurred in spite of major degrees of disproportion between the head and the smallest pelvic diameter. Suitable case studies to illustrate this point are shown in Figure 1, *A* and *B*, in which the interspinous diameter is the smallest pelvic diameter. Occasionally the true conjugate diameter may be the smallest pelvic diameter. In the case shown in Figure 11, *D*, Part III, the labor was terminated by an easy low forceps delivery in spite of the fact a major degree of disproportion existed between the fetal head and the true conjugate diameter. Serious difficulty, however, has been observed when no bony disproportion exists. The cases illustrated in Figure 1, *C* and *D*, show that an obstetrical prognosis is dependent upon factors other than accurate measurement of the head and the pelvic diameters. Experience has shown that a primigravida with an average or small sized child may require operative delivery while the same patient as a multigravida may deliver easily a larger baby. Furthermore, because of the marked variations in pelvic shape, the cardinal inlet diameters, even when accurately determined by roentgen methods, may fail to indicate the true obstetrical capacity and shape of any particular pelvis (Fig. 2). It is not always advisable to use the smallest pelvic diameter as an indicator of pelvic size because compensatory space may exist

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moulded, is deeply engaged in the left occipitotransverse position descending parallel to the sacrum. A major degree of disproportion (190 cc.) exists between the volume of the head and the volume of the interspinous diameter.

Anteroposterior diameter of inlet	10.0 cm.
Transverse diameter of inlet	12.5 cm.
Interspinous diameter	9.2 cm.

The long anterior and posterior sagittal diameters, *a* and *b*, compensate for the shorter transverse diameters which, with the backward inclination of the sacrum, allowed the head to descend through the posterior pelvis with the widest cranial diameter utilizing the space posterior to the narrow interspinous diameter.

C. Chart No. 540551. X-ray No. 167206. A white primipara, aged thirty-eight, was delivered by low medium forceps of a 2,950 gm. child after a labor of seventeen hours. Films obtained in labor show an ample anthropoid-gynecoid type of pelvis with straight side walls and a wide subpubic arch. The vertex, well flexed, is situated close to the symphysis in the right occipitotransverse position, *a*. Arrest occurred below the level of the spines in the right occipitotransverse to right occipitoposterior position. The head was so close to the pubic rami it was impossible to gain a good cephalic application of forceps. The head was brought down to a lower level in the occipitotransverse position and rotated anteriorly at the outlet. Arrest occurred because the head was held too close to the symphysis by the supporting structures of the lower uterine segment, *a*. As a result the ample space posteriorly could not be utilized. No disproportion exists between the volume of the head or any pelvic diameter.

D. Chart No. 437436. X-ray No. 155221. A white primipara, aged forty, was delivered by a caesarean section of a 3,430 gm. child because the head failed to engage after a short trial of labor. Films obtained in labor show an ample android type of pelvis with a flat tendency.

Anteroposterior diameter of inlet	11.0 cm.
Widest transverse diameter	14.3 cm.
Interspinous diameter	11.5 cm.

The fetal head did not engage because the supporting structures of the lower uterine segment held it too close to the symphysis causing it to impinge against the bone, *a*. There is no disproportion between the head and pelvis as estimated by comparison of head volume to the pelvic diameters.

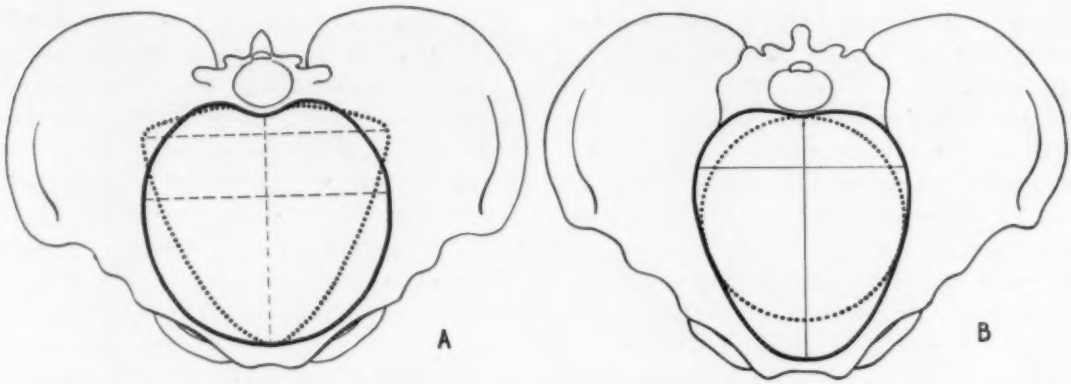

FIG. 2.* *A*. Diagram to show that standard inlet diameters may fail to indicate pelvic shape. Both pelves have similar anteroposterior and widest transverse diameters at the inlet but the inlet shape is different for each. *B*. Diagram to show difficulty of estimating the obstetrical capacity of the pelvis when the shape is abnormal. A circular disc fitted in the inlet gives a good index of inlet size (see Fig. 7).

* Courtesy Thomas Nelson & Sons. Fig. 68, Chapter X—Diagnostic Roentgenology—by Howard C. Moloy and Paul C. Swenson.

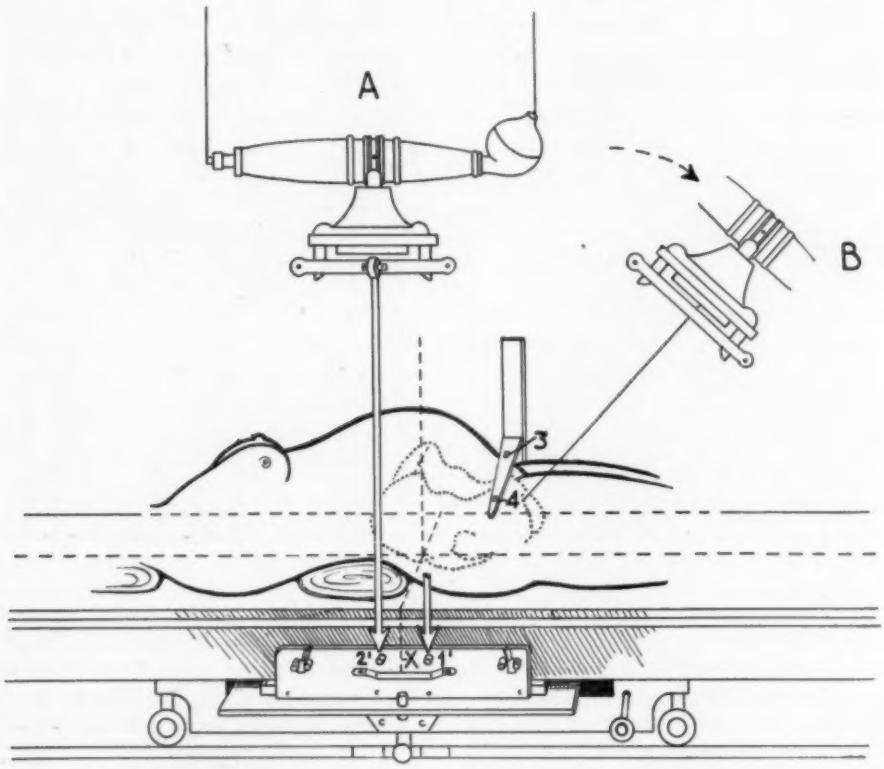

FIG. 3. *A*. Stereoroentgenograms. The patient is placed supine with the anterior superior spines perpendicularly above the midpoint, *X*, of the tube shift. Lumbosacral pad in place. The target placed at a 25 inch tube-film distance is centered for the first exposure over the center of the table and plumbed to peg *2'* of the casette frame fixed to the table edge. For the second exposure, the tube is shifted caudad 2½ inches and plumbed to peg *1'* of the casette frame. The known marker (*3* and *4*) is suspended just free of the lower abdomen above the symphysis. *B*. The 45° angle view of the subpubic arch. Lumbosacral pad removed. Target is moved downward and tilted at approximately right angles to the pubic symphysis and rami.

in front, behind, or lateral to this small diameter (Fig. 1, *A* and *B*). Estimation of the volume of the head fails to take into consideration the importance of head shape. Goodwin[13] has recently drawn attention to the significance of head shape in labor. Two general types may be recognized: the long oval and the round. The long narrow type of head usually flexes and moulds well, whereas the round head not infrequently moulds with difficulty.

Recently Pettit, Garland, Dunn, and Shumaker;[22] Steele, Wing, and McLane;[26] Scadron and Rappaport;[24] and Heaton[15] have reported upon the use of the roentgen ray in the study of pelvic morphology. All agree that the incidence of operative deliveries increases as the shape and size of pelves depart from the normal. Steele, Wing, and McLane[26] have been impressed with the errors in the clinical diagnosis of pelvic type as compared to the roentgenologic findings. Scadron and Rappaport[24] have appreciated the importance of the shape of the pelvis in the use of the obstetric forceps. Heaton[15] has observed the rarity of absolute disproportion and the frequency with which obstetrical difficulty occurs when no disproportion between head and pelvis exists. Obstetrical groups who make use of the roentgen ray as an adjunct in prognosis base their diagnostic approach upon the immeasurable factors. Roentgenologists for the most part have employed methods of roentgen pelvimetry and cephalometry. As a result, two schools of thought have developed which time and experience in the use of this diagnostic agent in obstetrics will eventually correlate. It is evident, however, that to gain accuracy in prognosis, more attention should be paid to the shape of the pelvis and to the manner in which the pelvic soft parts may affect the fetal-pelvic relationships.

THE TECHNIQUE OF PELVIO-ROENTGENOGRAPHY

The roentgenologic examination of the pelvis of pregnant women used in these studies consists of anteroposterior stereoroentgenograms, a lateral view to include the sacrosciatic notch, sacrum, and pubes, and a 45° angle view of the subpubic arch. During labor the view of the subpubic arch may be omitted.

The patient is placed in a comfortable supine position in the center of the Potter-Bucky diaphragm table (Fig. 3). A lumbosacral pad, just thick enough to prevent elevating the buttocks above the table top, is placed in the lumbosacral angle. This pad tends to maintain the pelvic inlet more nearly parallel with the film than would occur without its routine use. A marker, containing a triangular piece of lead imbedded at either end of a wooden strip with base lines exactly 9 cm. apart, is rigidly suspended over the region of the symphysis just free of the body. The marker may be supported by a sliding right angle arrangement from the side of the table, or more satisfactorily, by a heavy support placed between the patient's legs. In order to decrease magnified distortion and to insure the images being shown within the visual field, the markers must be held close to the symphysis rather than higher on the enlarged abdomen. The tube is shifted with precision 1¼ inches to each side of the center for the two stereoscopic exposures, using a 25 inch target-film distance and an 11 by 14 inch film.

In order to prevent the error caused by a shift of the film in the casette and of the casette in the tray, a frame is placed over the casette and fixed with precision to the edge of the table. The frame produces the image of arrow points around the periphery of the film for proper placement in the viewing box of the precision stereoscope. It will be observed that with each exposure the central ray bears a constant relationship to the arrow points on the frame, independent of the casette itself or its contained film (Fig. 4, *A*).

The shadow image of the arrows 5 and 6 (Fig. 4, *A*) bears a constant relationship to the tube for each shift. The target also bears a perpendicular relationship to one or the other of the arrows 1 and 2 for each

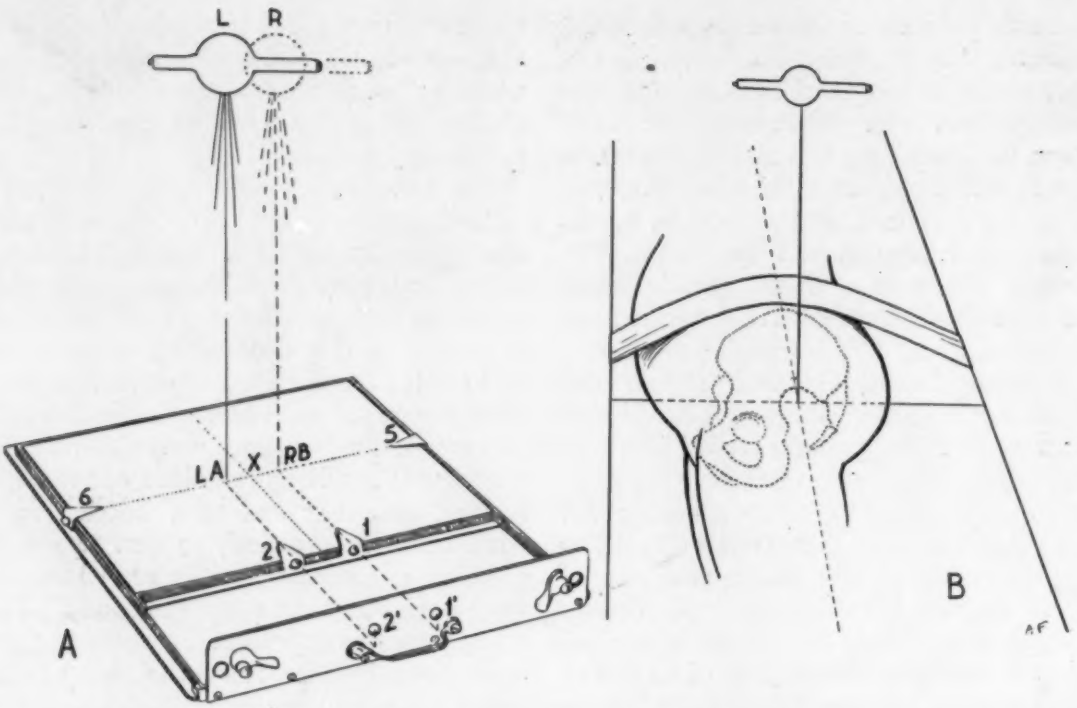

Fig. 4. *A*. Casette frame showing relationship of target for each shift to the arrow markers around the periphery. *X* = Base point. The target *R* and *L* at 25 inch target-film distance shifts along a common line joining arrows *5* and *6*. For each exposure note the perpendicular relationship of target along lines:

L, *LA*, *2*, *2'*, or *R*, *RB*, *1*, *1'*

B.* Lateral exposure to outline the sacrosciatic notch. The target is centered over depression just posterior to the greater trochanter of the femur. (Target-film distance 36 inches.)

* Courtesy Thomas Nelson & Sons. Fig. 25, Chapter X—Diagnostic Roentgenology—by Howard C. Moloy and Paul C. Swenson.

Fig. 5. Diagram to show the precision stereoscope in use. The film is placed in the view box with the image of the arrows *5* and *6* and either *1* or *2* of Figure 4 superimposed over corresponding lines permanently marked on the celluloid ledge of the view box.

shift. Accordingly, the film can be accurately placed in the view box of the precision stereoscope by shifting the films until the shadow image of the arrow points 5 and 6 and either 1 or 2 are superimposed upon corresponding lines permanently marked on a celluloid ledge around the viewing surface of the stereoscope (Fig. 5).

When we first started this work several years ago, an old type of curved Potter-Bucky diaphragm was used which had an optimum target-film distance of 25 inches. We have, for the sake of convenience, continued to use this type of Potter-Bucky diaphragm. The newer flat type of Potter-Bucky diaphragm, however, usually has a longer optimum target-film distance. The precision stereoscope can be adjusted to allow for a change to a 30 inch tube-film distance by widening the space between the optical system and film to 30 inches. The 2½ inch tube shift distance must not be altered with the increase in the target-film distance without a corresponding change in the rhomboid system and the reference points on the casette frame. A 2½ inch tube shift distance may be used with a 30 inch target-film distance without affecting the practical result.

Besides stereoscopic anteroposterior films of the pelvis, films of the subpubic arch and lateral films of the pelvis are obtained. For the subpubic arch film, the tube is moved downward approximately 13 inches from the midpoint of the original tube shift from which the stereoroentgenograms were obtained and is tilted at an angle of 45° toward the lower border of the symphysis (Fig. 3, *B*). As a result of this maneuver, the central ray is directed toward the subpubic arch at approximately right angles to the pubis and descending pubic rami. The pad is removed from the lumbosacral angle and a pillow placed under the knees to allow the inlet to regain its normal inclination by straightening out the lumbosacral angle and relaxing the iliofemoral ligaments. We routinely use a 10 by 12 inch film. For the lateral view, the patient is placed on her side in the center of the table. The tube, using a 36 inch tube-film distance, is centered directly above the depression just posterior to the greater trochanter of the femur. This depression anatomically corresponds to the sacrosciatic notch (Fig. 4, *B*). In order to superimpose the image of both notches, the sagittal plane of the sacrum must be parallel to the table top. This position may be aided by the use of a suitable pad under the body above the iliac crests. The body is immobilized by the use of a compression band. In laboratories suitably equipped the lateral view may be obtained from the standing position. This will show the effect of gravity in bringing the presenting part to the lowest level in the pelvis.

*The Precision Stereoscope (Figs. 5 and 6).** The principles of this instrument were conceived, proved experimentally, and applied practically by one of us (H. C. M.)[3] without knowledge of any similar method of measurement. However, Deville,[11] Davidson,[10] Drüner,[12] Trendelenburg,[29] Hasselwander,[14] Pulfrich,[23] and other workers, demonstrated and applied very similar principles many years ago. The first reference to this principle in American literature was made by Hirsch[16] in 1922 during a discussion of a paper by Thoms. He termed it the method of the "phantom ruler." We therefore claim no credit for originating the method, but convinced of its value, we have designed a practical instrument and standardized a technique for its use in pelvioroentgenography. The fact that the method has received no widespread recognition as a result of previous investigation is due to the extreme difficulty of duplicating the set-up of the original exposure in the stereoscope. Until we made use of the casette frame described above, the same difficulties were encountered. This addition to the technique makes the method reliable and practical.

The optical system of the stereoscope is

* The authors are deeply indebted to Mr. Kern F. Larkin of the Institute of Ophthalmology. Mr. Larkin's appreciation of our practical problems along with his knowledge of optical principles made possible the construction of a practical measuring stereoscope.

placed midway between the view boxes so that the distance between the eye of the observer and the film equals the original target distance. The optical system consists of first surface half-platinized mirrors (or better still, prisms) at an angle of 45° to the transverse axis of the stereoscope and a system of rhomboids. The rhomboids are essential to correct for variations in the interpupillary distances of different observers.

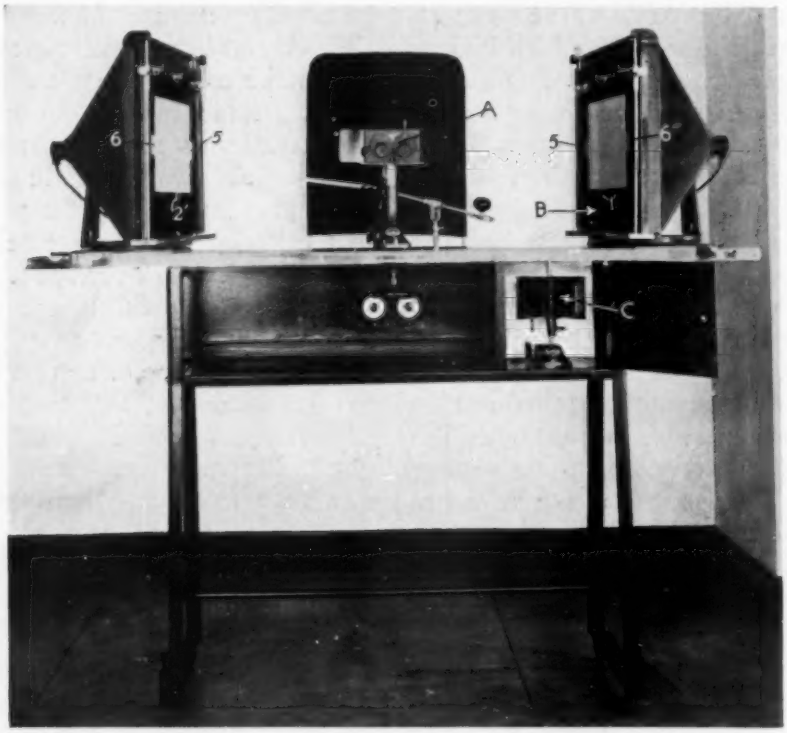

FIG. 6. A manufacturer's model of a combined general purpose (dual) stereoscope and precision instrument. The optical system and the kits for the viewing surface can be quickly attached for use in measurement of the phantom image. This combined instrument was developed following a suggestion by Dr. Ross Golden. If interest is restricted to pelvioroentgenography, an instrument with kits and optical system permanently mounted is more satisfactory. The arrow points made on the film by the casette frame (see Fig. 4, *A*) are superimposed over the lines *5* and *6* and *2'* for the left and *1'* for the right viewing surface These lines are permanently marked on the celluloid ledge of the kit. *A*, removable optical unit consisting of first surface, half-platinized mirrors and rhomboids to adjust for variations in the interpupillary distance; *B*, removable kits to fix over viewing surface; *C*, removable and adjustable mirror system for general stereoscopic work.

With the films in position and the light in the view boxes adjusted for varying degrees of film density, the observer may study a three-dimensional image of the fetal head and the pelvis similar to any other stereoscopic view. Because of the exactness of duplication of the conditions under which the films are exposed, the image should superimpose easily without eyestrain. A ruler is carried into the image and the known marker is measured in the spatial plane it appears to occupy behind the optical system. If the marker fails to measure its known length of 9 cm., the optical system is moved forward or backward, each movement changing the spatial plane and the size of the marker. When the marker measures its known dimensions, the image of the pelvis and fetal head is seen to bear the same size and shape as the original pelvis and fetal head presented to the roentgen-ray target. The cardinal diameters can be measured directly. The

observer carries a ruler into the correct spatial plane of the particular diameter desired. If the observer is attempting to measure the widest transverse diameter, for instance, at the inlet, the ruler must be carried into the correct spatial plane of the diameter before the measurement is determined. Incorrect measurements result if the ruler is held in front or behind the correct spatial plane. Considerable personal experience with the use of the precision stereoscope is necessary in order to develop accuracy in measurement. Roentgenograms obtained from a skeletal pelvis are recommended for practice in measurement. Transverse measurements of the inlet and of the interspinous and intertuberous diameters are most easily obtained. The length of the anteroposterior diameter or true conjugate is more difficult to measure for the inexperienced observer, because the anterior margin of the promontory and upper sacrum may be difficult to visualize. This difficulty can be overcome largely by decreasing the light in the view boxes to a minimum and by holding the ruler so that it becomes well illuminated by a small electric light placed for that purpose behind the optical system. This diameter is obtained at the level of the plane of the inlet rather than from promontory to symphysis. Accordingly, the observer must appreciate the slope of this plane and hold the ruler at the correct angle. A black cloth supported behind the optical system, against which the stereoscopic images are projected, is essential for contrast and is supplied with the manufacturer's model (Fig. 6).

When one is studying the stereoroentgenograms in the precision stereoscope, it is obvious in many instances that the pelvis is large enough to pass the fetal head and that no actual measurements are necessary. If, on the other hand, a pelvis of abnormal shape is found, measurements of the true conjugate, the widest transverse diameter of the inlet, and the interspinous and intertuberous diameters should be taken. In spite of ample measurements, many pelves will be found in which available inlet space is decreased because of the shape of the inlet. This complication is especially frequent in transversely narrowed pelves or in those with a narrow angle in the fore pelvis behind the sym-

Fig. 7. Chart No. 531089. X-ray No. 163706. A case study which illustrates the difficulty of determining the index of inlet size to compare with head size when the shape of the inlet is abnormal.

A white primipara, aged twenty-six, delivered by caesarean section of a 4,130 gm. child after an adequate trial of labor because the head failed to engage. The pelvis conforms to the extreme anthropoid type with definite transverse narrowing present throughout the pelvis. Films obtained in labor show a well-flexed large head in the right occipitoposterior position attempting to engage in the posterior pelvis.

Anteroposterior diameter of inlet....12.5 cm.
Widest transverse diameter of inlet....11.8 cm.
Interspinous diameter.....11.0 cm.

The largest circle which can be fitted into the inlet has a diameter of 11 cm. The circle which fits the biparietal diameter of the fetal head has a diameter of 10 cm. This indicates a definite degree of disproportion when allowance is made for the intervening soft parts. Comparison between the volume of the head and the smallest pelvic diameter indicated possibility of arrest unless available compensatory space was utilized.

physis. In such borderline cases, the observer who is certain of his ability to measure the phantom image in the precision stereoscope may reduce the degree of disproportion to mathematical terms in a way somewhat similar to the method suggested by Ball. Under stereoscopic vision he can determine the largest circle in the form of a cardboard disc which can be fitted into the pelvic inlet (Fig. 2, *B*). This maneuver gives the inlet size. A similar disc may be fitted into the fetal head and the largest disc which is estimated to fit the biparietal diameter gives an expression of head size to compare with the available inlet space. The application of this method of determining inlet capacity is shown in Figure 7.

REFERENCES

1. BALL, R. P. Roentgen pelvimetry and fetal cephalometry. *Surg., Gynec. & Obst.*, 1936, *62*, 798–810.
2. BALL, R. P., and MARCHBANKS, S. S. Roentgen pelvimetry and fetal cephalometry; a new technic. *Radiology*, 1935, *24*, 77–84.
3. CALDWELL, W. E., and MOLOY, H. C. Sexual variations in the pelvis. *Science*, 1932, *76*, 37–40.
4. CALDWELL, W. E., and MOLOY, H. C. Anatomical variations in the female pelvis and their effect in labor, with a suggested classification. *Am. J. Obst. & Gynec.*, 1933, *26*, 479–505.
5. CALDWELL, W. E., MOLOY, H. C., and D'ESOPO, D. A. Further studies on the pelvic architecture. *Am. J. Obst. & Gynec.*, 1934, *28*, 482–497.
6. CALDWELL, W. E., MOLOY, H. C., and D'ESOPO, D. A. Roentgenologic study of mechanism of engagement of the fetal head. *Am. J. Obst. & Gynec.*, 1934, *28*, 824–841.
7. CALDWELL, W. E., MOLOY, H. C., and D'ESOPO, D. A. Further studies on the mechanism of labor. *Am. J. Obst. & Gynec.*, 1935, *30*, 763–814.
8. CALDWELL, W. E., MOLOY, H. C., and D'ESOPO, D. A. The rôle of the lower uterine soft parts in labor. *Am. J. Obst. & Gynec.*, 1936, *32*, 727–753.
9. CLIFFORD, S. H. The stereoroentgenometric method of fetometry and pelvimetry with its obstetrical application. *West Virginia M. J.*, 1935, *31*, 401–414.
10. DAVIDSON, J. M. A method of localization by means of roentgen rays. *Arch. Roentg. Ray*, 1898, *2*, 64–67.
11. DEVILLE, E. On use of Wheatstone stereoscope in photographing surveying. *Tr. Royal Soc. Canada*, 1902–1903.
12. DRÜNER, L. Referred to by Cohn and Barth. Lehrbuch der Röntgenstereoskopie, Georg Thieme, Leipzig, 1931.
13. GOODWIN, J. C. Personal communication.
14. HASSELWANDER, A. Beiträge zur Methodik der Röntgenographie. II. Die Stereoröntgenogrammetrie. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1916–1917, *24*, 345–368.
15. HEATON, C. E. Pelvioradiography; clinical evaluation. *New York State J. Med.*, 1938, *38*, 83–87.
16. HIRSCH, I. S. Discussion. *Am. J. Obst. & Gynec.*, 1922, *4*, 316–319.
17. HODGES, P. C. Roentgen pelvimetry and fetometry. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *37*, 644–662.
18. JACOBS, J. B. Further improvement in pelvimetric roentgenography. *Am. J. Obst. & Gynec.*, 1936, *32*, 76–84.
19. JARCHO, J. The Pelvis in Obstetrics. P. B. Hoeber, Inc., New York, 1933.
20. JOHNSON, C. R. Stereoroentgenometry; method for mensuration by means of roentgen ray. *Am. J. Surg.*, 1930, *8*, 151–163.
21. MOLOY, H. C. New method of roentgen pelvimetry. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *30*, 111–114.
22. PETTIT, A. V., GARLAND, L. H., DUNN, R. D., and SHUMAKER, P. Correlation between the shape of the female pelvis and the clinical course of labor. *West. J. Surg.*, 1936, *44*, 1–20.
23. PULFRICH, C. Raumbildmeszgeräte für Stereoskopische Röntgenaufnahmen. *Ztschr. f. Instrumentenk.*, 1918, *38*, 17.
24. SCADRON, S. J., and RAPPAPORT, E. Evaluation of pelvioradiography and clinical pelvimetry in the course of progress of labor. To be published.
25. SCHUMANN, E. A. The size and shape of the pelvic inlet as determined by direct measurement. *Am. J. Obst. & Gynec.*, 1936, *32*, 832–835.
26. STEELE, K. B., WING, L. A., and MCLANE, C. M. Clinical evaluation of stereoroentgenography of female pelvis. *Am. J. Obst. & Gynec.*, 1938, *35*, 938–948.
27. THOMS, H. Roentgen pelvimetry; description of grid method and modification. *Radiology*, 1933, *21*, 125–130.
28. THOMS, H., and WILSON, H. M. Lateral roentgenometry of the pelvis—a newly modified technic. *Yale J. Biol. & Med.*, 1937, *9*, 305–309.
29. TRENDELENBURG, W. Ein neues Verfahren zur Raummessung an Stereoskopischen Aufnahmen insbesondere an Röntgenaufnahmen. *Wien. klin. Wchnschr.*, 1915, *28*, 169.
30. WEITZNER, S. F. A simple roentgenographic method for accurately determining the true conjugate diameter of the pelvis. *Am. J. Obst. & Gynec.*, 1935, *30*, 126–128.

Vol. 41, No. 3

PETROSITIS

A ROENTGENOLOGIC AND PATHOLOGIC CORRELATION*

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INTRODUCTION

PETROSITIS has been defined by Profant[11] as inflammation of the petrous portion of the temporal bone. In the strict anatomical sense, one should include all of the temporal bone medial and anterior to the squama in speaking of this disease. However, the part of the pyramid superficial to the superior vertical semicircular canal is in surgical parlance considered to be part of the mastoid. Therefore, it is logical to consider petrositis as inflammation of the remainder of the petrous pyramid. The word petrositis as used in this article therefore connotes an inflammation of the petrous bone medial and anterior to the arcuate eminence, which marks the site of the superior vertical semicircular canal.

As a complication of middle ear and mastoid disease, petrositis is becoming more and more a combined clinical and roentgenological problem. In spite of the classical works of Siebenmann,[14] Bezold,[2] and Gradenigo,[6] the petrosa was more or less disregarded in the study of otologic affections until recent years, but roentgenography and increasing research into the cause of meningitis as a complication of middle ear disease have served to focus the attention of the surgeon on the petrous pyramid, and his increasing interest has stimulated the roentgenologist to a more careful study of this portion of the skull. As surgical procedure has become standardized in regard to the mastoid region, the surgeon has become more and more concerned about the cause of continued drainage after mastoidectomy as well as other complications. The names of Eagleton,[3] Kopetzky and Almour,[8] Profant,[11] and Ramadier[12] are all closely allied to these recent investigations.

No longer is a roentgenographic study of the temporal bone in the lateral mastoid positions considered sufficient. The examination must include all portions of the temporal bone, including various projections of the petrous pyramid, as well as the mastoid process. Coincident involvement of the petrous pyramid or possible extension into it should always be anticipated in every case of mastoiditis, for we find that in pathologic material some suppuration in the petrous pyramid exists in all cases of otitis media. This is borne out by both clinical and roentgenographic evidence.

One of us (E.P.F.), working in the Department of Pathology of the College of Physicians and Surgeons of Columbia University has, during the past seven years, made routine serial sections of the temporal bone of all cases at the Presbyterian Hospital which came to autopsy with permission to examine the head. The authors have thus been able to correlate anatomical and pathological roentgen findings with those of necropsy. This presentation deals with a series of 29 cases showing roentgenographic changes in the petrous pyramids, and some observations on variations in the temporal bone as seen roentgenographically and in pathologic material.

When Gradenigo,[6] in 1904, described the syndrome of paralysis of the external rectus muscle and marked retrobulbar pain associated with otorrhea, he described a type of petrositis involving only a certain group of cells in the neighborhood of Dorello's canal. Since then, it has become increasingly evident that the picture may be varied according to the location of the infection and that there perhaps is no constant syndrome for petrositis. The multiplicity of possible symptom-complexes has been emphasized by Guild[7] in an analysis

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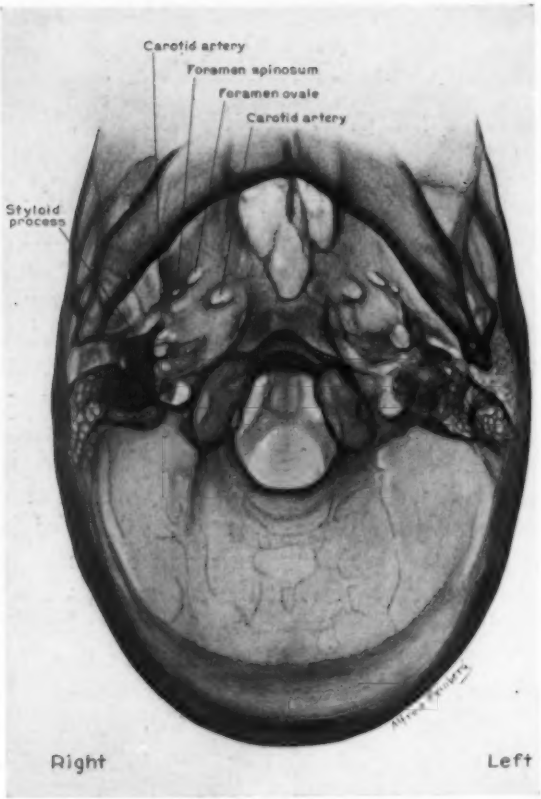

FIG. 1. Semidiagrammatic drawing traced from the roentgenogram of autopsy No. 11,129 showing the anatomy in a poorly penumatized case. The areas of decreased density in this case must not be confused with pneumatization when examining films taken in the mentovertical position.

of the various structures present in the petrous pyramid.

PNEUMATIZATION OF THE PETROUS BONE

Various figures on the amount of pneumatization of the temporal bone have appeared. Kopetzky and Almour[8] estimate that the petrosa is pneumatized in about 33 per cent of cases; Otto Mayer[9] estimates 25 per cent pneumatization and quotes other authors as follows: Belinoff and Balan, 35 per cent; Tato, 34 per cent; Kraus, 25 per cent; Tobeck, 13 per cent, and Brock, 11 per cent. Myerson[10] gives the figure as 11 per cent in a gross study of 200 embryonal, infant, and adult bones.

The foregoing figures are misleading because they are based on different methods of observation and on mixed age groups. It is very difficult to differentiate air cells from narrow spaces in dried specimens, and it is practically impossible to see all isolated air cells in the temporal bone roentgenographically. Thus statistics based on these methods of study are always to be questioned. Furthermore, since pneumatization varies with age, those authors who include material from children and embryos in their statistics will naturally report a low percentage of pneumatized bones.

The only reliable statistics are those based on serial sections, such as those of Otto Mayer.[9] Unfortunately, however, even he has not told just what constitutes pneumatization of the petrous pyramid and what does not. In our collection of 369 adult temporal bones, we have not been able to find a single one which did not have a cell or two somewhere in the petrous pyramid. The poorly pneumatized bones most commonly show cells around the eustachian tube, over the jugular bulb or in the epitympanum next to the exit of the great petrosal nerve. We have been able to find no pyramids which did not contain some marrow, although it is impossible to find marrow in some of our sections of the mastoid. Had these been taken more peripherally, we do not doubt that we would have found more instances of small marrow spaces in and about the mastoid cells. The incidence of a high degree of pneumatization in the petrous pyramids examined was low, hardly more than a dozen cases. We have, however, 14 cases (proved at necropsy) of inflammation of the petrous pyramid posterolateral to the anatomical tip (antelabyrinthine region), in which the pneumatization varies from an extensive to a comparatively slight air content. It apparently is not essential, therefore, to have a high degree of pneumatization in order to have petrositis.

Various unproved theories regarding the mechanism of pneumatization of the temporal bone have been proposed. The most generally accepted theory is that of Wittmaack,[17] who believes that the temporal

bone is pneumatized by an invagination of the mucous membrane of the middle ear into the primitive marrow spaces. Thus, when a temporal bone is found to be non-pneumatized, this is due to a failure of the mucous membrane to have invaginated into the marrow spaces. A sclerotic mastoid would therefore always be a developmental accident rather than due to infection in the mastoid process. This theory is opposed by others who point out that infection in bone can itself produce sclerosis which is responsible for the lack of pneumatization. Wittmaack, being well aware that many sclerotic mastoids have a history of long-standing infection, suggests that this infection produces fibrosis of the muco-periosteum of the invaginating lining which, in turn, prevents the normal invagination of the air-filled sac from the middle ear. He goes so far as to say that this infection may even start *in utero*.

Eckert-Möbius[4] contends that the pneumatization of the mastoid is produced by stress and strain on the bone just as the bony spicules in the bones of birds are produced and as are also the complicated truss-like bone bridges in such long bones as the femur and tibia in man. The primary process in pneumatization then would be bone growth with secondary invagination of the air-filled mucous membrane. He also feels that if infection in the bone occurs it produces sclerosis which prevents this secondary invagination.

More logical than these hair-splitting controversies as to which came first, the bone growth or the invagination of the air-filled mucous membrane, is the work of Rüedi[13] who finds in a large series of embryos and of infants that the size of the middle ear and the mastoid, and the pneumatization of each, show wide variation whether or not there is infection in the middle ear. Moreover, he feels that the normal pneumatization of the temporal bone is usually a hereditary affair like the size of the head, the length of the long bones of the body, etc.

We feel that it is not absolutely necessary to decide which theories of pneumatization of the temporal bone are correct. For our purposes it suffices to assume that the mastoid and petrous air cells are the result of invaginations of the mucous membrane of the middle ear, and that certain temporal bones are congenitally more sclerotic than others, and further, that if an early infection occurs in the temporal bone, sclerosis is likely to result. A point less certain but none the less useful is that the temporal bones usually develop symmetrically, so that comparison between a normal and a pathological temporal bone is as a rule justified.

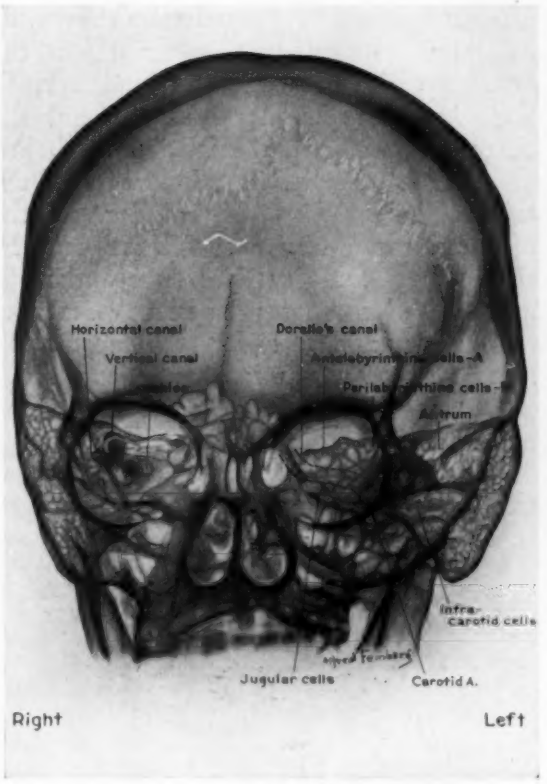

FIG. 2. Semidiagrammatic drawing of roentgenogram of autopsy No. 11,259 showing a highly penumatized mastoid and petrosa in a normal case. Compare Figures 3 and 4.

PNEUMATIZATION AND INFECTION

Although corrosion specimens and dissections showing air cells throughout the petrous pyramid were described by Bezold[2] and Siebenmann[14] in 1897, this fact is very

often forgotten. In our material they most commonly occur just anterior to the arcuate eminence beneath the labyrinth and above the jugular bulb, around the eustachian tube, and occasionally below and behind the horizontal portion of the carotid artery. The remainder of the pyramid consists of labyrinthine capsule, thick bone of the cortical type and fatty marrow. This marrow changes according to the demands on it for blood formation just as does the fat marrow of the other long bones. In pernicious anemia, lymphatic leukemia, etc., it may take on the hyperplastic appearances characteristic of the disease of the bone marrow in question. In early life the bony partitions between the air cells and the marrow are very thin and constantly changing. Furthermore, areas can usually be found when the partitions are absent so that if infection occurs in the air cells it is very quickly, either directly or by breaking of the thin partition, transmitted to the neighboring marrow (Fig. 5). Thus, in a mastoid containing both marrow and air cells such as one usually finds in a child, one invariably finds a combination of empyema of the air cells and an osteomyelitis of the surrounding marrow tissue. This type of infection produces the so-called "hemorrhagic mastoid" encountered in children. In adults, a large quantity of marrow in the mastoid process is rare although it does occur (Figs. 6 and 10). In the petrous pyramid, on the contrary, there is rarely, if ever, complete pneumatization; that is, no complete replacement of the marrow by air cells, so

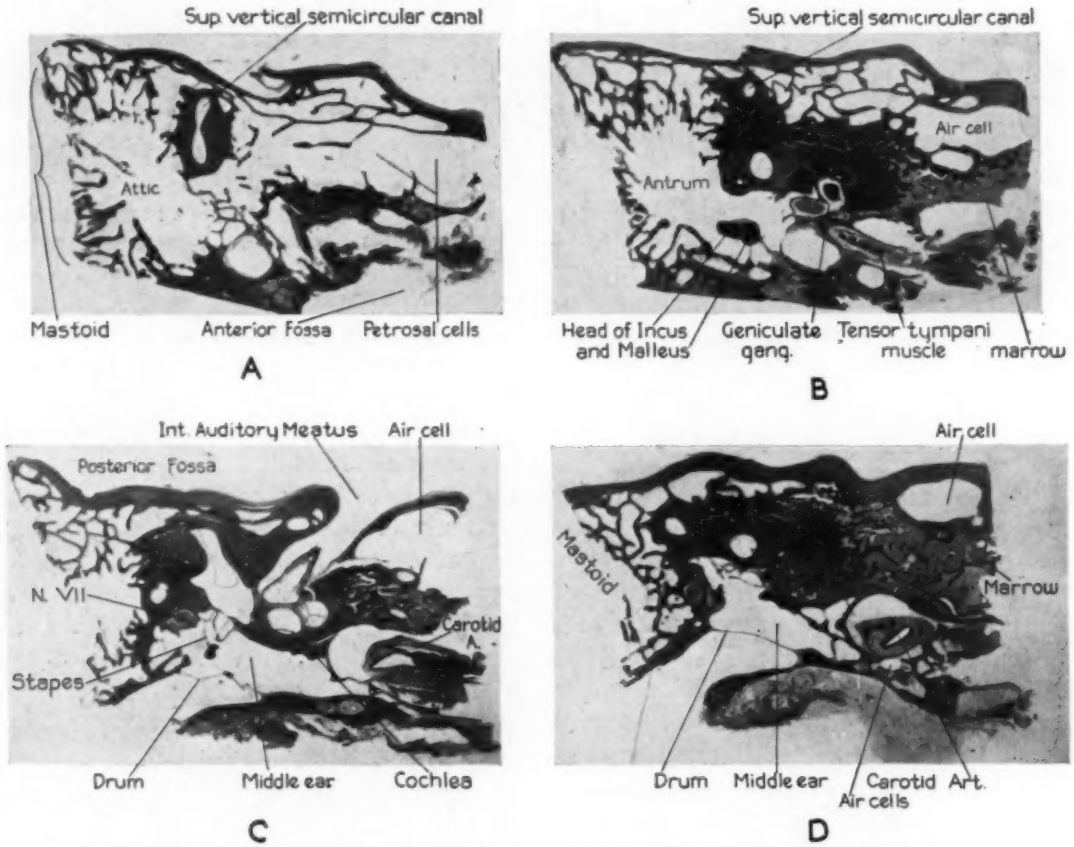

FIG. 3. Horizontal serial sections through the left temporal bone of autopsy No. 11,259 from above downwards. Compare Figures 2 and 4. Note that the air cells in the mastoid are continuous with the attic, and that those in the petrosa are also continuous in the upper section, *A*. A group of cells are present behind the superior vertical semicircular canal in *A* and *B*. A large air cell is also found anterior to the internal auditory meatus and behind the carotid artery in *C* and *D*.

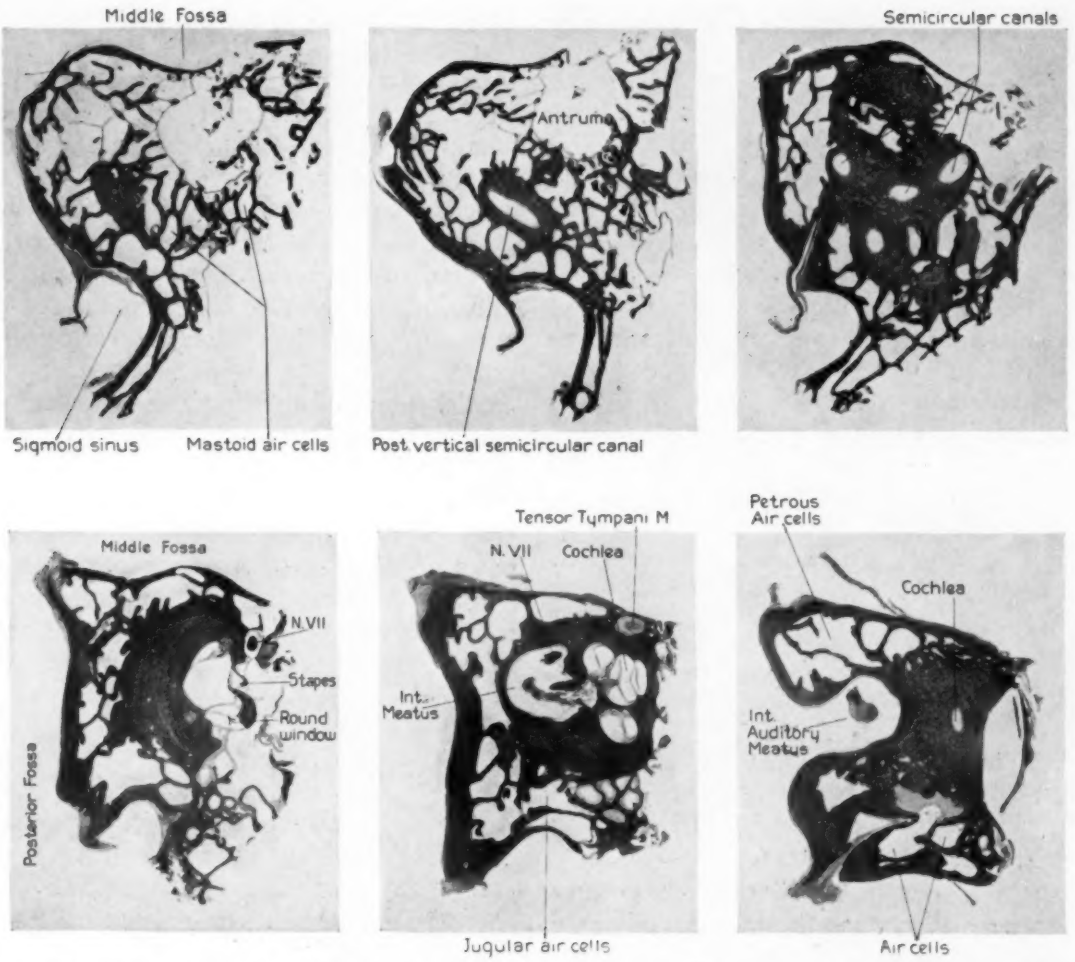

FIG. 4. Vertical serial sections through the right petrous pyramid of autopsy No. 11,259. Note density of bone about the labyrinth. Sections are from the outside inward. Compare Figures 2 and 3.

that if an infection occurs and progresses in these cells, there is invariably not only an empyema of the type commonly recognized in the mastoid process, but there is also an infection of the surrounding marrow spaces producing a secondary osteomyelitis (Figs. 7, 8 and 9).

This osteomyelitis is usually a low grade affair and is manifested simply by replacement by the marrow tissue by bone with resulting sclerosis of the petrous pyramid (Fig. 11). Marrow is a tissue extremely resistant to infection. However, if an infection gains a foothold in the marrow, it is very difficult to stop and is very likely to persist or recur, as is well known in the study of osteomyelitis of the long bones. There is no reason to believe that marrow

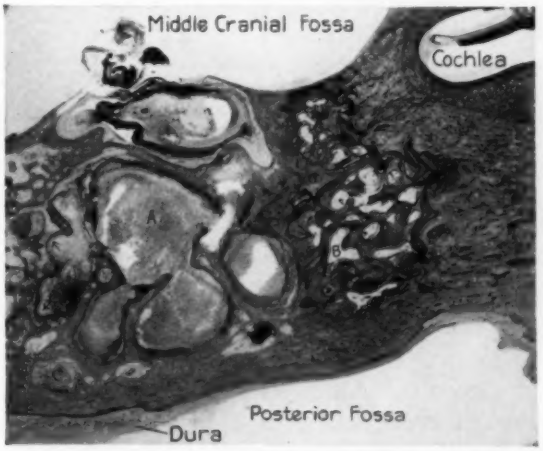

FIG. 5. Horizontal section through the temporal bone showing infected air cells, *A;* fat marrow, *B*, and hematopoietic marrow, *C*. Arrows indicate points where the infected air cells are invading the marrow cavities.

FIG. 6. Vertical section from the mastoid region of a poorly pneumatized case. Note the sclerotic bone about the antrum and the marrow tissue inferiorly.

of the temporal bone should behave any differently than does the marrow of other bones of the body. If the infection in the marrow is fulminating it breaks down cortical boundaries, produces subdural abscesses, and if these subdural abscesses break into or through the dura, meningitis or brain abscess supervenes. There are many venous connections between the petrous pyramid and the large sinuses of the skull, as well as connections between the vaso vasorum and the carotid artery and the arachnoid space. These blood vessels are thought to be one of the pathways by which infection extends to the meninges.

Meningitis of otic origin, with rare exceptions, occurs in cases of long-standing or recurrent ear infection, especially if a cholesteatoma is also present. The probable reason for this is that the infection has produced bone and scar tissue in the region around the middle ear, thus walling off the more peripheral areas from the natural drainage point. The infection then attempts to obtain drainage, and the shortest route is very often through the cortex either into the middle or posterior fossae from the zygomatic region, the lateral sinus or more rarely through the lower surface of the petrous pyramid into the nasopharynx. Occasionally the infection may break through the labyrinthine capsule into the labyrinth (Fig. 12). The breaks in the cortex can sometimes be seen on roentgenograms.

The extent of an infection in the mastoid is largely dependent upon the amount of pneumatization, because it is through the pneumatized spaces that the infection is transmitted. In pathological specimens, cases of infection of the middle ear always show more or less involvement of the surrounding pneumatized bone; that is, with middle ear disease, there is always some

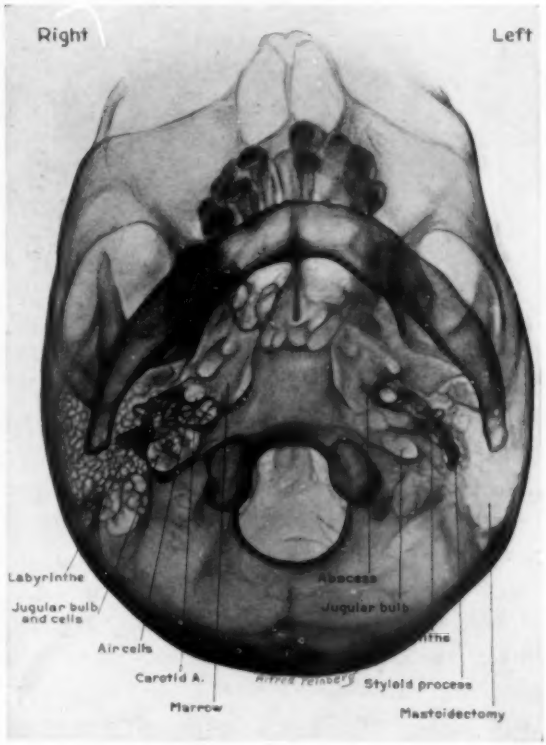

FIG. 7. Semidiagrammatic drawing of Case XXII (autopsy No. 11,522). Patient died of a meningitis following an abscess in the left petrous pyramid. Compare Figures 8 and 9. Note the anatomical landmarks seen in Figure 1.

degree of mastoiditis and petrositis if there is pneumatization in the petrous pyramid. Infection is therefore always present in the cells within the petrosa when there is infection of the mastoid. The pneumatization of the petrous pyramid is, however, usually less extensive than the pneumatization of the mastoid, which accounts for the fact that a simple mastoid operation and consequent proper drainage of the middle ear will permit drainage of the cells elsewhere in the temporal bone (see Fig. 14 and Case IV).

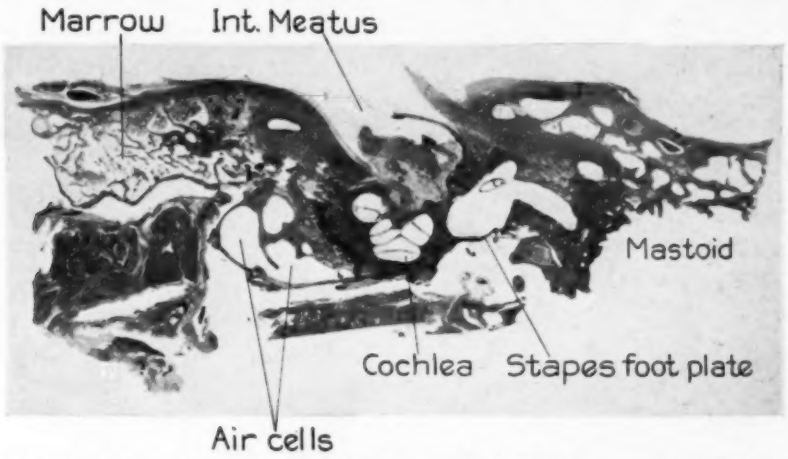

FIG. 8. Horizontal section through the region of the stapes of the right normal temporal bone of Case XXII (autopsy No. 11,522). Compare Figures 7 and 9.

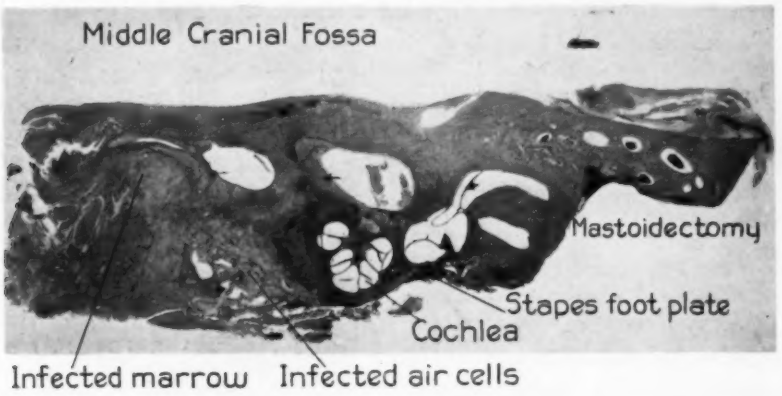

FIG. 9. Section of the left temporal bone at the level of the stapes of Case XXII (autopsy No. 11,522). Note large abscess cavity replacing air cells and marrow seen in Figure 7. (Temporal bones have been reversed for comparison purposes.) Note that abscess breaks into internal auditory meatus at a point shown by the arrow.

ROENTGEN TECHNIQUE

The petrosa is relatively inaccessible for roentgenographic study. This perhaps explains why detailed studies have been made only recently. It lies deep and, in order that it be roentgenographed, its shadow must be projected through the cranial vault and through considerable soft tissue as well. Our routine projections have been: first, the usual Law mastoid position modified to a certain degree by using the Bullitt mastoid apparatus (Fig. 15); secondly, the so-called "mentovertical" or "verticomental" film of the skull base recommended by Taylor (Fig. 14); and thirdly, the oblique positions (Stenvers' or more usually the reverse Stenvers') (Fig. 18), so as to obtain a profile view of the petrosa. Occasionally, so-called "exaggerated base"

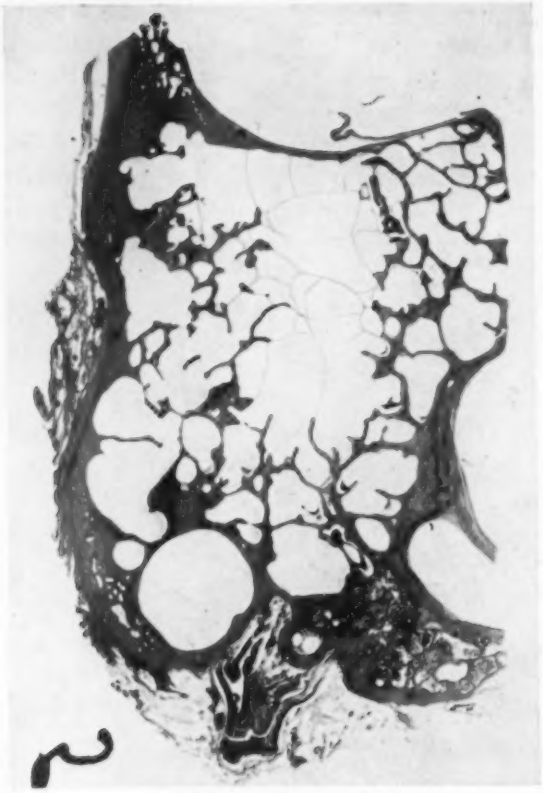

FIG. 10. Vertical section through the mastoid tip of a normal, relatively well pneumatized case (specimen by courtesy of Professor Karl Wittmaack, Hamburg).

skull films (Mayer's position) can be made with these in an attempt to get a caudad-cephalad projection of the skull base (Fig. 17), several angles being tried, so that profile views of the various surfaces of the pyramidal-shaped structure can be obtained. Occasionally, also, direct antero-posterior films of the skull with the superior angle of the petrous ridge projected through the orbits may be of value (Figs. 2 and 16).

ROENTGENOLOGIC MANIFESTATIONS

It is well to point out that, even when the petrosa is well pneumatized, the same roentgen findings usually may not be, or cannot be expected to be seen as in an acute suppurative mastoiditis. This is because pus-filled cells may be entirely obscured by an overlying shell of bone, whereas the air cells are usually clearly visualized in a suppurative mastoid process, because they are more superficial and more numerous. Not until petrositis has gone on to the point where a good deal of decalcification in the surrounding bone shell occurs or until the process has actually broken through the cortex, can the disease be demonstrated at times. Toward the superior angle, however, the perilabyrinthine cells are more easily visible and can be observed and judged much as those in the mastoid process.

As Taylor[16] has pointed out, there is usually some change in the density of the pneumatized petrosa whenever there is an acute mastoiditis. It remains a very difficult differential problem to ascertain when such a lesion actually requires surgical intervention, especially when it is known, from studying pathological specimens, that in every petrous pyramid there is always some petrositis associated with mastoiditis. Whatever suppuration may be present is usually taken care of by the drainage following a simple mastoidectomy or even a myringotomy. Thus, very few cases of petrositis, *according to our aforementioned definition*, require special surgical intervention.

Another important point to be stressed is that there may be an asymmetry be-

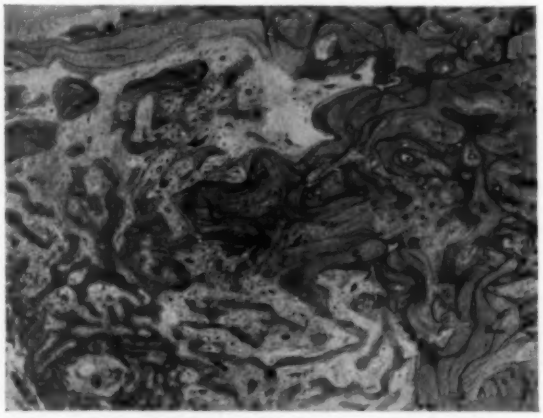

FIG. 11. Case XXIV (autopsy No. 11,863) showing low grade chronic osteomyelitis in the left side of the cut. It involves most of the antelabyrinthine region producing the increased density seen in Figures 22 and 23.

tween the two petrosae which has existed throughout life. Failure of pneumatization of the type seen in the so-called "infantile mastoid" also occurs in the petrosa and is usually due to infection of the middle ear early in life. A careful history is therefore essential in the study of these cases.

Depending upon the extent of pneumatization, and the three types of pathological processes that may be present, there is a varying roentgen picture. If the petrosa is well pneumatized, paralleling for the most part the extent of pneumatization of the squama and mastoid tip, empyema of these cells produces at first an increased density like that in the cellular mastoid. As this progresses, there is usually a decalcification of the surrounding cortical bone, then an ill defined appearance with a generalized decreased density supervenes. If, later, the infection breaks through, forming an epidural abscess, one can often recognize actual breaks in the cortical outline (Fig. 17). It is obvious that in the development of such a process, one small group of cells may be infected but completely buried and hidden by the surrounding non-pneumatized bone (Fig. 12). In these early cases, it is important to have a preliminary film made at the time of the first otologic examination so that the finer changes may be recognized by comparison should petrositis develop. Though it may seem unnecessary to some, yet early films are essential for good management of the routine case and the occasional great help justifies the greater effort and expense.

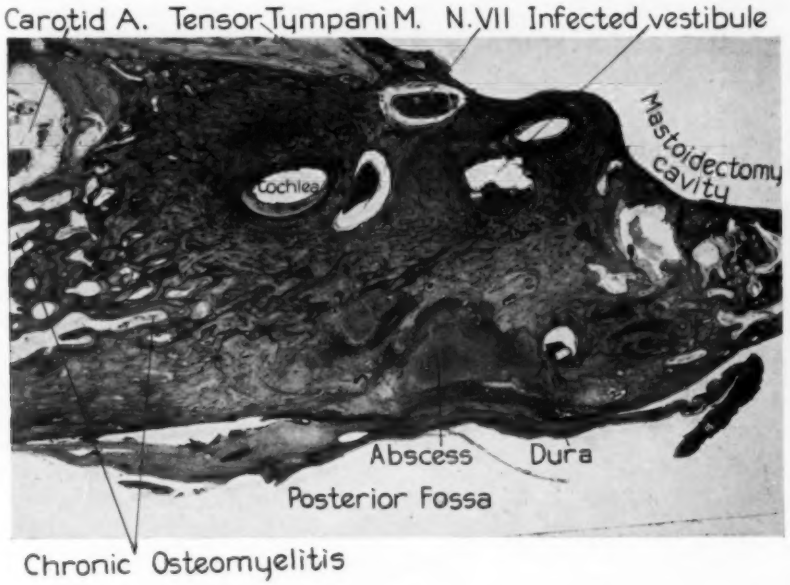

Fig. 12. Case xxi. F.T. (autopsy No. 12,041). Abscess of perilabyrinthine region in chronic osteomyelitis of the petrous pyramid in a case which had discharging ear for twenty years. Arrow shows where the abscess broke into the superior vertical semicircular canal producing labyrinthitis, meningitis and death. Note that the abscess has broken through the cortex to the dura, but that the dura is thickened and intact. The abscess was entirely too small and buried behind the labyrinth to show roentgenographically, but the chronic osteomyelitis showed as increased density in the petrous pyramid.

When infection occurs in a non-pneumatized petrosa, an actual osteomyelitis develops and then the changes are like those of an osteomyelitis elsewhere. It takes time for the process to become apparent by roentgen ray and, unless the destruction is very rapid, the productive change in the surrounding bone usually predominates to the extent that an increased density is the outstanding feature. The surrounding bone is stimulated to a fibro-osseous reaction

and bony condensation becomes apparent. Smoldering foci may be completely hidden within the more or less sclerotic bone. It has been our experience that there is almost always a combination of empyema, osteitis and osteomyelitis, so that an increased density in the involved petrosa is the rule rather than decreased density (cf. Fig. 11).

CLASSIFICATION OF CASES

It is apparent from the histological and roentgenographic and clinical studies that there are several types of petrositis, apparently dependent upon the anatomy of the bone involved. It is doubtful, however, whether anatomy is the only factor. The chronicity plus the virulence of the infecting organisms, as well as the general resistance of the patient, the adequacy of drainage naturally or artificially produced, etc., all play a part. We are segregating our cases into four more or less broad groups.

Group A (7 cases) were those showing roentgen evidence of petrositis but which subsequently became well, clinically, without specific operative interference in the petrous pyramid.

Group B (7 cases) were those which showed roentgen evidence and occasionally clinical signs of petrositis which were treated by simple mastoidectomy but which then continued to show some evidence of petrositis, although they are fairly well and going about their daily routine.

Group C (3 cases) were those cases showing clinical evidence of petrositis and which were operated on for petrositis with special technique with subsidence of symptoms.

Group D (12 cases) were those cases showing clinical evidence of petrositis who, with or without operation, died of meningitis.

Abstracts and illustrations of representative cases in each group follow.

CASE REPORTS

Group A

CASE I. E. A., male, aged eight (X-ray No. 122159. Unit No. 311508).

The patient was admitted to the Vanderbilt Clinic with a left earache of two days' duration.

Myringotomy was performed two days later, and hemolytic streptococcus recovered. The right drum broke spontaneously and hemolytic streptococcus and *Staphylococcus aureus* were recovered.

Films of the temporal bones showed them to be highly pneumatized. There was a diffuse clouding of all the cells in both the mastoid and petrosal portion of the bone without definite breaking down of the cell septa.

Two years later both ears were dry, only a small perforation being found in the left drum.

Comment. This was apparently an early petrositis which, like the mastoiditis, healed spontaneously after myringotomy.

CASE II. M. R., female, aged twenty-two (X-ray No. 133325. Unit No. 450270).

The patient was first seen in the Vanderbilt Clinic complaining of left earache of two days' duration. Myringotomy yielded a small amount of exudate. One week later she developed a profuse discharge containing hemolytic streptococci. After five more days there was sagging of the posterior canal wall, a great deal of pain and a temperature of 102° F. Films at this time showed that the patient had very highly pneumatized temporal bones with diffuse clouding of the cells on the left side. This extended into the zygoma and into the pneumatized portion of the petrous bone. It was felt that the ordinary myringotomy opening would be insufficient to drain so extensive a surface as must be present in this highly pneumatized bone and a simple mastoid operation was done somewhat earlier than is usual.

At operation cells were found filled with scattered pockets of pus, but there was very little breaking down. Postoperatively the patient did well except that the discharge was more profuse than usual.

She was readmitted six weeks later because of a temperature of 102° F., pain over the left side of the head and behind the left eye. There was discharge from the posterior mastoid wound at that time. The canal was dry. Roentgenograms of the petrous pyramid showed increased density in the petrosa without definite areas of bone necrosis.

The patient was followed in the clinic and the wound reported dry three months after the operation. She has had occasional slight pains in

the left ear, but there has been no recurrence of infection. Occasionally she has had slight headaches, attributed to syphilis. When last seen almost three years later, there was no complaint about the ear.

Comment. This case illustrates the value of early roentgen examination to determine the anatomical structure of the temporal bone. She was operated on early because of the high degree of pneumatization present, and this early drainage prevented persistent deep infection in the petrosa.

Case III. W. P., male, aged twenty-nine (X-ray No. 133022. Unit No. 450668).

This patient had a history of running ear of five months' duration. He had had periodic attacks of abscess with spontaneous rupture of the drum and discharge for three or four days.

Films of the mastoids showed extensive pneumatization throughout both sides with diffuse clouding on the left extending into the cells of the petrosa.

Hearing was decreased on the left.

A simple mastoidectomy was done soon after admission.

An uneventful convalescence followed.

One year later the wound was well healed and the canal dry. He had no complaints at that time.

Comment. The heavy shadow cast by the petrosa in this case may well be due to the repeated mild infections that the patient suffered in former years rather than to the eipsode for which he was operated on.

Case IV. M. C., colored female, aged twenty-two (X-ray No. 133245. Unit No. 450758).

This patient gave a history of earache of five days' duration with external otitis as well as an acute purulent otitis media.

The external otitis was improved markedly by radiotherapy, but the mastoiditis progressed. Films of the temporal bone showed a diffuse clouding of the entire pneumatized portion of the mastoid and petrous pyramid. Both the mastoid and petrous portion of the temporal bone were considered well pneumatized. A simple mastoidectomy was performed two weeks after admission. Considerable breaking down of the mastoid cells was found. The mastoid area showed isolated groups of infected cells with sclerotic areas between.

Fig. 13. Mentovertical projection of Case III, W.P., showing a high degree of pneumatization on the right and clouding of the petrous pryamid on the left.

The patient was dressed routinely. The mastoid wound was healed and the canal reported dry one month after operation.

She was last seen one year later, at which time she had no complaints referable to her ear. (See Fig. 14.)

Comment. This case showed quite marked changes in the petrosa roentgenographically but ran a quite ordinary course after simple mastoidectomy.

Case V. J. S., female, aged seventy-five (X-ray No. 142099. Unit No. 465897).

Admitted to the clinic with a history of discharging ear of two and one-half months' duration with some pain in the ear at first. There was no headache or fever.

She had been followed in the clinic for some time and was admitted because of persistent thick, yellow discharge containing hemolytic streptococci. There was sagging of the posterior superior canal wall. Roentgenograms showed generalized haziness through the petrous portion of the right temporal bone.

FIG. 14. Case IV. M.C. Mentovertical projection showing a high degree of pneumatization on the left and clouding of the cells of the petrous pyramid on the right. Compare Figure 15.

A simple mastoidectomy six days after admission showed a large mastoid with two separate and distinct pockets of pus under moderate pressure.

A culture from the mastoid showed pneumococcus Type III.

Postoperatively, the patient had a fever which ran as high as 101.8° F. at first; later as high as 102° F. for several weeks. The wound granulated very rapidly, the superficial granulation shutting off deeper drainage, and this was thought responsible. Finally the infection was controlled and she was discharged two months after operation with a dry ear and healed wound.

Comment. The persistent temperature in this case was undoubtedly due to the infection in the petrosa which was not at first adequately drained by the operation.

CASE VI. S. S., male, aged fifty-four (X-ray No. 107276. Unit No. 372621). (See Fig. 16.)

The patient came into the clinic complaining of discharge from the left ear, pain over the left mastoid and headache of six weeks' duration following a head cold.

Roentgenograms of the mastoids showed diffuse clouding of the entire mastoid and petrous portions of the temporal bone.

A culture from the discharge showed *Staphylococcus aureus*, *Staphylococcus albus*, and a few pneumococci.

A simple mastoidectomy was performed and a tremendous mastoid cavity was exenterated.

Postoperatively, the course was not unusual except that the patient developed a horizontal nystagmus toward the lesion on the day following the operation. Two days following the oper-

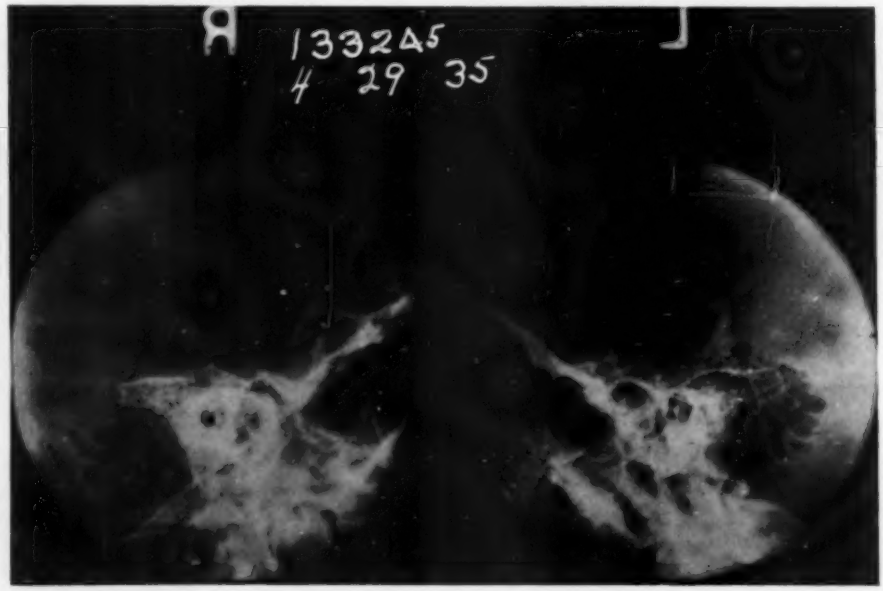

FIG. 15. Case IV. M.C. Projection in the standard Law position showing slight clouding of the mastoid cells on the right and a moderately well pneumatized mastoid.

ation the patient developed chills and a temperature of 105° F., but this dropped to normal after twenty-four hours. The blood culture was negative. He was finally discharged to the clinic, only to be readmitted two weeks later because of a constant temporal headache on the left side with occasional boring pain behind the left eye. A neurological examination at that time was negative.

He developed another chill with temperature up to 105° F. on the third day and again to 104° F. on the fourth, with a negative blood culture.

Antrum and sphenoid irrigations were done and very few shreds of mucus obtained, but he felt better after this and after one month his ear was reported dry and again one year later.

Case vii. A. B. (private patient of Dr. S. Daly), female, aged eleven (X-ray No. 140940. Unit No. 435140).

The patient was admitted to Babies Hospital with a history of discharging ear, headache, and diplopia off and on for three months. She was found to have a draining right ear, right external rectus paralysis and some nystagmus on looking to the left.

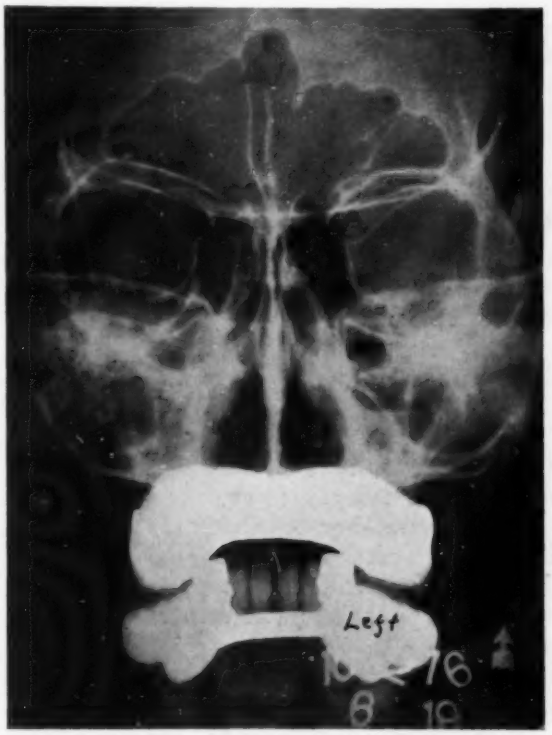

Fig. 16. Case vi. S.S. Clouding of the petrous pyramid on left in a highly pneumatized case as seen in the posteroanterior view.

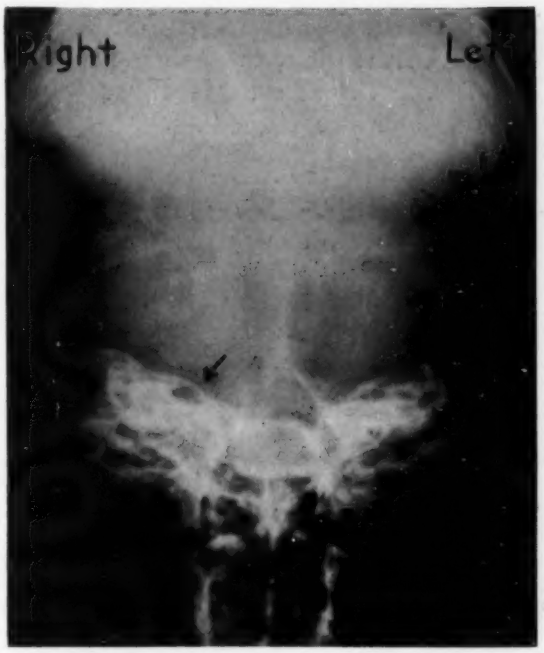

Fig. 17. Case vii. A.B. Occipital position showing a large area of decreased density in the region of Dorello's canal in a case which had Gradenigo's syndrome. Complete cure after simple mastoidectomy.

Films of the petrous pyramid showed a large area of diminished density in the region of the gasserian ganglion on the right. This was apparently an actual break in the cortex (Fig. 17).

A simple mastoidectomy was performed, and after a few days the external rectus paralysis diminished and the temperature came down to normal and the patient was discharged.

The patient returned eleven days later with severe headache, return of external rectus paralysis and fever of 101° F. Revision of the mastoid was done and a few zygomatic cells found. There was a culture of hemolytic *Staphylococcus albus* and pneumoccus.

The posterior auricular wound continued to drain for six weeks.

She was last seen twenty months later, at which time films of the skull still showed an area of thinning near the gasserian ganglion on the right. No symptoms of mastoiditis or petrositis were present.

Comment. Here is a true case of Gradenigo's syndrome which recovered after simple mastoidectomy but subsidence of symptoms took some time and the convalescence was long. Apparently there was an absence of the cortex in the region of

Dorello's canal through which the infection reached the sixth nerve. It is difficult to say whether the defect seen in Figure 17 is anatomical or pathological.

Group B

CASE VIII. A. S., female, aged thirty-nine (X-ray No. 101441. Unit No. 356035).

The patient gave a history of running ear on the right of three weeks' duration, with dizziness, intermittent right temporal and parietal headache and pain in the right ear. A right mastoidectomy had been done ten years ago followed by intermittent discharge from the ear. There was nystagmus on looking to the left. A foul discharge was found in the ear canal and polypoid mucosa could be seen through a large perforation in the drum.

Films of the mastoids and petrosae showed pneumatic type mastoids with relatively small cells. There was complete loss of cellular detail on the right, with marked clouding of the petrosa from base to apex, but no appreciable bone destruction.

A radical mastoidectomy was done shortly after admission.

The patient's course was uneventful except that for some time after the packing was removed the temperature rose to 101° F. and there was profuse discharge from the canal. Granulation tissue was quite extensive in the cavity and had to be controlled with strong silver nitrate.

The ear continued to discharge in spite of frequent dressings for seven months.

The last follow-up two years later showed a dry cavity and no complaints except tinnitus occasionally.

Comment. This case illustrates the somewhat longer course and persistence of temperature after operation due to the deep-seated infection.

CASE IX. A. S., female, aged twenty-five (X-ray No. 144950. Unit No. 483419).

The patient gave a history of headache, vomiting and dizziness of six weeks' duration.

She had had bilateral acute purulent otitis media fifteen years ago; since when she had had four operations on the left mastoid and one on the right mastoid. There have been no symptoms since the last of these.

Roentgenograms of the mastoid showed a few residual cells along the margins of the sinus wall on both sides and diffuse clouding throughout the pneumatized petrosa on the left.

Hearing was diminished in the left ear-conduction type. A small amount of cold water in the left ear produced a reversal of her horizontal nystagmus.

She was last seen one year after the last revision operation and claimed to be very much improved. She had no temperature and no discharge from the mastoid cavity and no leukocytosis.

Comment. This case is an example of recurrent otitis media and mastoiditis. The whole picture is probably due to a chronic osteomyelitis of the petrosa as indicated by the roentgen findings.

CASE X. F. W., female, aged twenty-one (X-ray No. 137366. Unit No. 463830).

The patient gave a history of pain in the right ear of three weeks' duration. She had had a chronic draining ear off and on for seventeen years. A radical mastoidectomy had been done five years ago with a revision three months later. There had been continual discharge since the revision, and for the past three weeks an elevated temperature of 101° F.

On admission the patient had headache, nausea and vomiting. Films of the mastoids showed marked clouding and there was marked increase in density of the petrous pyramid on the right.

An audiogram showed complete loss of hearing for air and bone conduction on the right. Vestibular response was within normal limits, though slightly more active on the right.

A revision of the right mastoid cavity was done on admission.

The patient was discharged five days later, feeling quite well. The cavity was fairly clean but continued to discharge.

She was readmitted one month later with a temperature of 101.2° F., and severe supra-orbital headache and pain in the back of the neck. The sedimentation rate was found to be 14 mm. in an hour. White count 10,000 with normal differential. The temperature remained about 100° F. for four days and then came back to normal.

Vestibular tests showed marked impairment of the labyrinth on the right.

Two months postoperatively the cavity was reported clean and dry.

One month later the discharge returned with

frontal headache from time to time for two years.

Comment. This case is typical of the entire group. There is increased density in a non-pneumatized petrous pyramid suggesting chronic osteomyelitis. There is intermittent return of the symptoms, discharge, dizziness and pain.

Case xi. C. B., female, aged thirty-eight (X-ray No. 58560. Unit No. 86229).

The patient was admitted to the Vanderbilt Clinic complaining of pain in the back of the right ear and right temporal region, with dizziness and a tendency to fall to the right, of three weeks' duration. There was nausea but no vomiting. She gave a history of having been operated on for mastoiditis at the age of six and had repeated operations at various hospitals since.

Audiogram showed an average of 30 decibels loss on the left and 55 decibels on the right. Vestibular reactions were normal.

A right radical revision was attempted and a few purulent cells were found at the bottom of the mastoid cavity.

After this, she was seen in the clinic off and on, occasionally complaining of dizziness, occasionally complaining of pain and blurring vision.

A new revision of the right radical mastoidectomy was done one year later with some relief for a short time.

Five years later the patient was admitted to the medical ward because of possible bronchopneumonia, but on careful study her temperature was found to be due to the chronic infection in her temporal bone. She also gave an interesting history that she felt better when her ear was running, or after one of her numerous operations. There was never pain behind the eye or sixth nerve involvement.

Films of the petrous pyramid at this time showed an increased density and loss of architectural structure on both sides.

Since then she was followed in the clinic always with the same complaints until after two years she came in with considerable swelling in the pre-auricular region on the left. Biopsy of this region several weeks later showed some inflamed lymphatic nodules.

She was last seen six years after the last revision operation, with the same complaints, i.e., discharging left ear, pain in the left temporal region and occasionally dizziness.

Fig. 18. Case xii. B.W. Oblique view of the petrous pyramid (reversed Stenvers') showing air cells in the petrous pyramid on the left side. Note that there is apparent clouding of the petrous cells although this is the normal side. This cloudy appearance is due to superimposed tissues.

Comment. This case began at an early age when there could have been very little pneumatization of the petrosa. She undoubtedly has a chronic infection on both sides which occasionally flares up causing pressure symptoms. With operation or spontaneous drainage the pressure is relieved and the pain and dizziness disappear.

Case xii. B. W., female, aged forty-six (X-ray No. 130333. Unit No. 444045).

There was a history of swelling of the right side of the face, paralysis of the left side of the mouth of two weeks' duration. She had had a pain in the right ear with some discharge for two months until two weeks before admission, when the discharge dried up. At this time, she developed increased swelling in the right zygomatic region and a left lower facial palsy.

FIG. 19. Case XII. B.W. Reversed Stenvers' position of the pathological side showing marked increase in density throughout the petrosa with loss of cell structure outline. Compare Figure 17.

Films taken by a local doctor at that time show evidence of mastoiditis, but her ear was dry and the swelling was so far in front of the ear that we did not connect it with her ear, so nothing was done; moreover, the patient was a Christian Scientist and wanted nothing done. Only in the last few days has she admitted feeling ill and the right ear has been discharging again. The patient claimed no previous otitis symptoms.

A simple mastoidectomy was done on February 1, 1935, and a large abscess uncovered in the right zygoma with evidence of bone necrosis and new bone formation at this point. The dura appeared healthy; the sinus, however, had a gray unhealthy appearance.

The culture from the mastoid showed pneumococcus Type III and hemolytic *Staphylococcus aureus*. The large mastoid cavity did not heal very well and has continued to discharge off and on ever since. The left facial paralysis has healed with the associated movements characteristic of a peripheral lesion.

She was readmitted one year later with a history of intermittent headache and persistent discharge. Roentgenograms showed a highly pneumatized temporal bone on the left with diffuse clouding of a bone of similar structure on the right. This was apparently a diffuse condensing otitis throughout the petrosa characterized by a diffuse increase in density. In spite of her religious beliefs she would occasionally admit to paroxysms of deep eye pain, and she felt unable to return to work for many months. Occasionally she was dizzy. The headache and the discharge finally cleared, she claims, and she was last seen on August 12, 1936, with a dry ear but some residual left facial paralysis.

CASE XIII. F. J., female, aged six (X-ray No. 14190 (B.H.). Unit No. 317689).

There was a history of cold three weeks before admission with a slight cough but no fever. Four days before she had a temperature of 101° F. and slight pain in the right ear. Two days before, paracentesis was performed with escape of thin yellow pus. Subsequently there was a temperature of 103–104° F. with vomiting, and the patient was then admitted.

A physical examination at that time showed a thick sanguineous clot in the right canal, no prolapse of the posterior wall, slight mastoid edema, pneumococcus Type V culture.

Films of the mastoids showed clear septal markings in highly pneumatized mastoids. There was less pneumatization on the right than on the left with no evidence of breaking down.

On this admission, temperature dropped to normal. The patient was discharged to continue treatment at home.

Second admission: There was a history of measles since first admission and of a cold three weeks before, at which time she developed pain in the right ear five days before there was discharge from the right ear with temperature up and down to 105° F.

Physical examination revealed the left ear to be negative. The right ear showed moderate seropurulent discharge, a large perforation in posterior inferior quadrant but no sagging of canal wall. There was some tenderness on deep pressure over the mastoid antrum and tip.

Films of the mastoids again showed variation of the air content on the right side. She was again discharged after a few days in the hospital with conservative treatment to the ear. On the day of discharge, her temperature rose to 104° F.; she was readmitted three days later.

Third admission: A cloudy right maxillary

antrum was found; this was irrigated. She continued to have fluctuating temperature. Soon the left ear became involved and both began to drain profusely.

On February 13, 1934, a right simple mastoidectomy was done at which patchy areas of sclerosis interspersed with infective granulations were found, but no free pus. There was some degeneration of the cellular septa which appeared like caseated material, but this was not cholesteatomatous. The mastoid was naturally large.

Postoperatively the patient continued to run a slight temperature of 101° F. daily. Finally, on February 25, 1934, a left simple mastoidectomy was done and free pus with many degenerated septa was found; that is, the usual picture of empyema of the mastoid was encountered. Investigation of the right mastoid cavity was made and it was found to be filled in nicely with healthy granulations; a few cells were removed from the squamous and zygomatic regions.

She was discharged to be followed in the clinic.

Films of the petrous pyramid a few weeks after discharge showed decreased air content on the right, suggesting probable exudate or fibrosis in the pyramid.

The patient was followed in the clinic where excess granulation tissue from both wounds was cauterized with silver nitrate. Dressings were changed daily week after week. The mastoid wounds were healed by May 31, 1934, but there was continual discharge from the canals and in the nasopharynx.

Fourth admission: Revision of the mastoid on the left was done on July 10, 1934. Several fairly large cells were found in the zygoma and in the region of the sinodural angle. There was also an extension of cells deep to and behind the semicircular canals. Following operation, both ear canals discharged very much less. She was discharged from the hospital with a partially healed wound on the left, which remained so.

Fifth admission: Radical left mastoidectomy was performed because of the persistent discharge from the wound; after this, the discharge continued. Films of the petrous pyramid on April 15, 1935, however, showed no definite asymmetry between the two sides.

June 28, 1935, was the first time that her ear was reported healed and dry. Since then, except for one slight exacerbation of discharge from the posterior wound, the canal has been dry and the posterior wound has been healed.

Case xiv. R. S., male, aged seven (X-ray No. 20183 (B. H.). Unit No. 244865).

The patient was admitted on May 14, 1934, with a history of otitis media of two weeks' duration on the right, a stiff neck of two hours' duration, a right external strabismus of one day's duration, and an erythematous area on the right cheek which is anterior to the eye. From the right canal there was a profuse purulent discharge and marked sagging of the posterior wall.

Films of the temporal bone showed a highly pneumatized bone on both sides with diffuse clouding of the mastoid and petrosal cells on the right. There was no evidence of septal destruction.

A simple mastoidectomy was performed and showed an unusually large mastoid for a child of seven. There was some free pus in the superficial cells which seemed to be under pressure. The bone in the region of the right horizontal canal was very dense. No extension of the cells into the petrosa was seen. After this operation, the left ear began to discharge and finally after a left postauricular swelling had developed, a simple mastoidectomy was performed on the left ear. This was also exceptionally large and deep and, in all respects, resembled the other side. After the second operation, the patient improved and up to September 5, 1936, the right side was said to be entirely healed and dry. The left was comparatively dry. The right external rectus had regained a good deal of its function.

Roentgen examination showed a difference in density in the two mastoids, with probable exudate in the right mastoid tip.

The child returned to the clinic showing sluggish granulations on the left side. These were treated with silver nitrate. On December 19, 1934, the wounds were finally reported dry with no granulations or dermatitis around them. On February 19, 1936, the child returned with excoriation and dry scabby material over the mastoid bone. In three days both ears were dry. The excoriation was completely gone. On February 19, 1936, he again came in complaining of a purulent discharge from the right ear, temperature of 102° F., and pain about the orbit. In spite of repeated efforts to find him, he has now been lost to this clinic.

FIG. 20. Case XV. J.L. Posteroanterior view showing increased density and loss of detail in the petrous pyramid on the left.

Culture of the pus from both sides showed hemolytic streptococcus.

Comment. Most of these cases had radical mastoidectomies and show the chronicity of the disease when not properly drained. It is interesting that all of these cases show increased density roentgenographically in the petrous pyramid suggesting chronic osteomyelitis or at least a diffuse osteitis. The high incidence of recurrence of symptoms in this group is also noteworthy.

Group C

CASE XV. J. L., male, aged seventeen (X-ray No. 111080. Unit No. 384759).

The patient was admitted on July 15, 1933, with pain behind the left ear one week with severe headache keeping him awake at night. Earache was present one month before when myringotomy was performed, purulent discharge continued from ear since myringotomy. On July 17, 1933, a simple mastoidectomy was done on the left. An unusually large mastoid was found. There was a broken down area in the posterior part of the tip and all the cells contained granulations and a yellowish exudate.

Postoperatively, the canal became dry quickly and the patient was discharged on August 4, 1933.

On August 6, 1933, he returned to the clinic complaining of pain in the left ear, pain above the left eye, nausea and fever. He was found to have a left external rectus paralysis.

Films of the mastoids show that the mastoid had been well cleaned at the previous operation, but the petrous pyramid was diffusely clouded so that the individual cells are obliterated in marked contrast to the good pneumatization on the right.

Culture from the mastoid wound showed hemolytic streptococcus. The wound was reopened and a fistula found. Considerable thin yellowish fluid was found exuding from the cells behind the semicircular canal. Curetting in the region above and behind the eustachian tube yielded a small amount of thin hemorrhagic exudate.

The external rectus paralysis cleared up by August 24, 1933, but the discharge from the posterior wound continued. Even after discharge from the hospital, the patient still complained of pain in the left side of the head and behind the left eye until late in November, 1933, at which time he was readmitted for observation. Lumbar puncture was negative. Another operation on the mastoid was performed and all granulation tissue removed from the middle ear and mastoid cavity. There was a tract behind the horizontal canal leading toward the petrous pyramid. This was enlarged.

Postoperatively, the mastoid cavity continued to discharge for some months and on August 20, 1934, he was again admitted. A few granulations were removed from the middle ear. A new fistula was seen above the eustachian tube and a plastic repair done behind the auricle.

The patient was last seen on August 22, 1936, at which time there was a large crust in the cavity but no real discharge and no complaints except moderate deafness in the left ear.

CASE XVI. G. P., male, aged thirty-nine (X-ray No. 131572. Unit No. 446044).

The patient was first seen in the clinic on March 11, 1935. He came in with an acute running ear on the right side of four days' duration. He had had an acute discharging ear ten years before. Films of the temporal bone showed very extensive pneumatization in the mastoid, zygomatic and petrous regions. The cells on the

right were a bit hazy compared to those on the left.

Simple mastoidectomy was done on March 21, 1935, and considerable pus and granulation tissue were found in the mastoid cavity. Postoperatively, there was considerable discharge from the wound, but he was finally discharged, only to return on April 3, 1935, still complaining of a stiff neck, headache, blurred vision and projectile vomiting. He showed at this time a positive Kernig and slight papilledema. Lumbar puncture showed 1,200 cells, no organisms.

Films of the petrous pyramid (Fig. 21) showed a distinct defect in the cortex, just anterior to the superior vertical semicircular canal on the right. This was exposed by Dr. Kernan through a modified gasserian ganglion approach and a distinct cavity containing thick yellow exudate under pressure was evacuated in the region just anterior to the superior vertical semicircular canal. A rubber drain was inserted in this cavity and the patient showed slow improvement until May 1, 1935, when a plastic repair over the mastoid cavity was done. After this he continued to discharge a small amount until September 16, 1936, when he was readmitted with blurring of vision in the right eye following a cold. The ophthalmologists, however, were unable to find any evidence of pathology. Roentgen examination of the petrous pyramid showed complete obliteration of the cellular structure on that side, while on the left there was pneumatization out to the anatomical tip. After a few days in bed the blurred vision disappeared and he was last seen June 25, 1937, when he had no complaint.

Case xvii. (Previously reported[5].) G. S., male, aged seven (X-ray No. 76366. Unit No. 265188).

He was admitted in December, 1930, with a typical left otitis and mastoiditis. A simple mastoidectomy revealed a high pneumatic mastoid and many scattered cells filled with yellow pus. The upper part of the posterior wall was broken down as well as the mastoid tip and the sinodural angle. After operation the patient had a high temperature for a few days and continued to discharge a serous exudate from the external canal for many months. One year later, December 11, 1931, he was admitted for a modified left radical mastoidectomy. The canal was found to be markedly narrowed by proliferation of bone along the posterior wall. The middle ear and antrum were filled with granulation tissue, but the remaining cells of the mastoid were surprisingly healthy. On December 27, there was a rise in temperature associated with swelling behind the ear. This continued to discharge and produced a large amount of granulation which necessitated curetting and application of silver nitrate. By February 25, 1932, he had begun to complain of pain in the left eye and a low grade fever had developed.

Fig. 21. Case xvi. G.P. Mentovertical projection showing highly pneumatized normal petrosa on the left and clouding of the petrous pyramid on the right. Operative drainage of abscess along petrosal ridge followed by recovery.

Films of the skull in the mentovertical position, and stereoroentgenograms in the posteroanterior projection, showed the right petrous pyramid to be pneumatized at its tip. A little farther out its shadow was markedly increased in density. The stereoroentgenograms showed an apparent destruction of the upper margin of the left petrous bone beginning at its anatomical apex and extending laterally 2.5 cm. It looked as though this destroyed area began only about 1 cm. inward from the point where the mastoid operation left off. The picture was quite characteristic of petrositis.

Dr. Kernan operated, March 9, and reported that the cavity of the previous operation, which embraced the mastoid and the middle ear, was found to be full of soft granulations and pus. There was an area of necrosis with a fistula in the roof of the eustachian tube. The fistula led to an abscess supposed to be near the tip of

the petrous portion of the temporal bone. The bone underlying the granulation tissue had a soft wormy appearance.

An incision was made along the line of the previous scar. The ear was turned forward. All the granulation tissues were scraped out of the mastoid cavity and middle ear, and the bony wall exposed. The facial canal, promontory, oval window, carotid, canal and eustachian tube were all identified. When the probe was being passed into the eustachian canal a fistula was found leading upward and inward, which exuded about 1 drachm (4 cc.) of thick pus. The tegmen tympani was then taken away and all bone in the region of the eustachian tube, exposing the area of the fistula. The cavity was packed with iodoform gauze and the wound was left wide open.

After the operation the pain in the eye disappeared and the aural discharge slowly decreased in amount. In three months the canal was dry but a small sinus developed which drained serous fluid for still another three months. Now, six years after the last operation, he is perfectly well and there has been no discharge from the ear.

Summary of Group C. This group represents those cases operated on by special surgical procedures. A distinct cavity was present in a petrosa more highly pneumatized than the average in each instance, and when this region was properly drained the patient recovered.

Group D

CASE XVIII. (Previous reported[5].) O. B., colored male, aged thirty-nine (X-ray No. 131572. Unit No. 446044).

He first had a mild ache in the left ear four weeks before his admission to the hospital. Two weeks before admission a left-sided frontal and parietal headache developed for which he consulted a physician. The latter treated him for sinusitis without relief. The day before admission the patient had quite a severe headache, but he managed to work all day.That evening he began to vomit and then quickly became delirious. He was admitted next morning to the medical wards in a coma with a temperature of 106.5° F. and all the classic signs of meningitis. There was slight bulging of the left drum, but no pus appeared after myringotomy. Examination of the throat, chest and abdomen was entirely negative. The spinal fluid contained 130,000 cells per cubic millimeter, with 89 per cent polymorphonuclear neutrophils and pneumococcus Type III. Culture of the blood was negative. He died twenty-four hours after first going into coma.

Roentgenograms in the mentovertical position taken after death show a definite washing out of the cells of the tip on the left side. There is some thickening of the cell walls on both sides suggestive of a chronic disease of long standing or repeated attacks of otitis. Curiously enough, however, when the temporal bones were removed there was very little gross difference between the two sides. Perhaps the left petrous tip was a bit more succulent, but several observers were unable to be sure of any disease in either side. However, microscopically there is a vast difference. The temporal bones are of the pneumatic type. On one side the cells are filled with a purulent exudate, consisting of large mononuclear cells and occasional polymorphonuclear neutrophils. The cell walls are thick and in many places there is a regrowth of pink staining bone as well as areas of osteoid, which suggests a chronic as well as an acute process. There is a mild inflammatory process in the cells of the mastoid and petrous on the right. Here, too, there may have been a chronic osteitis. It is significant that grossly this lesion was not apparent. After all, the surgeon sees the lesion grossly and in this case he would have found no creamy pus and he would have found no necrotic bone. With the hemorrhage always present in mastoid operations, this bone would have looked perfectly normal to him.

The mode of invasion of the meninges in this case is problematic. There is no break in the dura, microscopically. With the low power of the microscope, however, many small cells are seen to drain into the vessels of the dura. Since this is a common finding in ordinary mastoiditis, one is forced to the theory that the virulence of the organism in this case was responsible for the infection of the meninges.

CASE XIX. M. H., male, aged fifty (X-ray No. 143698. Unit No. 480875. Path. No. 12066).

The patient was admitted on March 2, 1936, with a history of pain in the right ear for four days with spontaneous rupture. Two days before admission a right myringotomy was performed because of return of pain. At this time the patient was beginning to show meningitic symptoms. Temperature was 103° F. Died within twenty-four hours. Cell count of spinal

fluid was 1,650. Pneumococcus Type III culture from ear.

Films showed increased density at the base of the petrous pyramid in the perilabyrinthine and inferior carotid cells. The cells about the mastoid antrum were also cloudy.

Autopsy showed acute suppurative leptomeningitis. Sections of the petrous pyramid showed a few air cells in the regions anterior to the labyrinth. These were filled with purulent material on the right. There was practically no bone destruction and only in one small area invasion of the marrow.

Comment. Both of these cases are of a rapid type which it seems at present impossible to arrest clinically. The first showed considerable evidence of previous inflammatory reaction in the pyramid, the second oddly enough did not.

Case xx. O. D., female, aged forty-three (X-ray No. 133397. Unit No. 450850).

The patient was transferred from the Neurological Institute on April 25, 1935, with a history of an upper respiratory infection of ten days' duration. One week before admission to this hospital, a bilateral myringotomy was done for severe mastoid tenderness and pain behind both ears. Since that time, there has been a profuse discharge from both ears and increasingly severe pain behind the ears. There has been a temperature of 101–102° F. and the patient felt acutely ill. There has been no dizziness. The patient gives a history of having frequent attacks of earache since childhood. She has never had drainage from the ears, however, and thought her hearing had been quite normal.

Bilateral simple mastoidectomy was performed on April 28, 1935, because of the terrific tenderness, pain, and high temperature of this patient. The right mastoid showed almost complete breaking down of the mastoid cells, especially those between the sinus and the posterior canal wall. The sinus, however, appeared normal except for the inferior portion where there may have been dehiscences. On the left side, a similar huge mastoid cavity was found filled with pus pockets. There was no preoperative exposure on this side, however. Postoperatively, the temperature dropped to normal, but by the next evening her temperature was again 103.6° F. The drainage from both wounds was exceptionally great. The temperature continued to spike to 105° F. and on May 3, 1935, the jugular vein was tied on the left and a thrombus found in the left sigmoid sinus.

Films of the petrous pyramids showed a little clouding of a highly pneumatized bone, but no haziness of outline or diminution in density.

On May 7, 1935, a lumbar puncture showed 1,500 cells and 84 per cent polymorphonuclears. The patient went rapidly downhill. Hemolytic streptococcus was recovered from her blood and spinal fluid. She died on May 10, 1935, two weeks after admission.

Autopsy showed a diffuse acute pachymeningitis and leptomeningitis, and a bilateral acute osteitis and osteomyelitis of the petrous portion of the temporal bone due to hemolytic streptococcus.

This case is an example of a virulent infection which, in spite of everything that was done, went on to meningitis and death with extraordinary rapidity. This type of case apparently occurs with highly pneumatized bones and hemolytic streptococcus infections.

Case xxi. F.T., male, aged twenty-eight (X-ray No. 142509. Unit No. 477666. Path. No. 12041).

The patient was admitted on January 30, 1936, complaining of vomiting and dizziness. The patient first began having intermittent discharge from the right ear twenty years before. This continued for ten years.

Two and one-half months before admission, the ear began to run again, associated with some pain over the mastoid on the right side of the head. One week before admission, there was pain in head and behind right eye.

Films showed slight increase of density in the petrous pyramid and a sclerotic mastoid, but no evidence of a break in the cortex.

Blood culture showed pneumococcus Type III as did also spinal fluid.

The patient died the second day after admission.

Autopsy revealed acute leptomeningitis, chronic right mastoiditis, acute right labyrinthitis.

Sections of the temporal bone showed chronic osteomyelitis of the petrous portion of the temporal bone and a small abscess behind the labyrinth which had broken into the posterior arm of the superior vertical semicircular canal (Fig. 12).

The abscess which produced this patient's demise was too small and too well hidden by

cortical bone to be seen by roentgen examination. There was evidence of a low grade infection in bone and marrow to be seen in both roentgen examinations and pathological sections.

CASE XXII. G. H., male, aged forty-one (X-ray No. 118549. Unit No. 407586. Path. No. 11522).

First seen in the clinic, complaining of pain in left side of face and draining left ear of five days' duration. Moderate discharge from ear had been present until February 23, 1934, when a myringotomy was performed due to bulging of the drum. Culture of the drainage showed *Staphylococcus albus*.

He had had a myringotomy on the right ear three years before, after which drainage had subsided.

Left simple mastoidectomy was done on March 1, 1934, and a very large pneumatic type mastoid was found. Culture from this showed *Staphylococcus albus* and pneumococcus Group IV (old terminology).

Postoperatively, he continued to complain of severe pain over the left eye and temporal region.

Diplopia and paralysis of the left external rectus was first noted on March 9, 1934.

The mastoid was reopened on March 13, 1934, and nothing unusual was found. The patient continued to have discharge from the wound; the canal became dry, however, the external rectus paralysis persisted as did the supra-orbital pain. The temperature was normal in the morning but even while the patient was bedfast thirty-one days after the original operation, the temprature rose to above 100° F. every evening.

On April 4, 1934, the Eye Clinic noted that the external rectus paralysis had disappeared. He was discharged to be followed in the clinic in spite of his mild pain.

On April 10, 1934, he was readmitted in a semicomatose condition. There was still discharge from the mastoid wound. The patient died on April 11, 1934.

Autopsy showed almost complete destruction of the petrous portion of the temporal bone, osteomyelitis of the diploic portion, empyema of the pneumatized portion and a pneumococcus Type III leptomeningitis. The invasion was through the internal auditory meatus (Fig. 9).

Note that this, too, was a case of long-standing infection before the process caused meningitis and death.

CASE XXIII. L. G., female, aged thirty-nine (X-ray No. 117389. Unit No. 405116).

Admitted to the hospital on January 22, 1934, complaining of severe pain in the ear of three days' duration. Five years before admission, following tonsillectomy, patient developed buzzing in the right ear, and noticed a slight tenderness on that side. She went to another hospital and was told that the canal of her ear was filled with a hemangioma. This was treated on three occasions. The buzzing stopped and the patient did not return to the hospital. Two months ago her right ear began to discharge, and this has persisted up to the present.

Physical examination on admission showed nothing significant except chronic inflammation about the right external auditory canal. Just inside the meatus was a large, pale, white polypoid mass, apparently arising from the anterior inferior surface of the canal. Over its surface was considerable purulent material. There was tenderness over the right mastoid bone posteriorly.

Films showed the cells on the left to be large and quite extensive. On the right there was blurring of the cellular septa in the mastoid, squamous and petrous portion of the temporal bone.

Cultures from the ear showed hemolytic streptococcus and *Staphylococcus aureus* predominant.

A simple mastoidectomy was done on January 22, 1934, and average cell pneumatic type was found. There was a very small amount of pus over the dural plate, and the dura itself appeared bluish and unhealthy. There was no breaking down of the mastoid proper and it contained only a small amount of thin pus and granulation tissue. In the external canal there was a large hard mass attached to the anterior canal wall. This bled quite profusely on removal with a snare. It extended the entire length of the canal to the drum membrane.

Pathological examination of this mass revealed it to be a capillary hemangioma.

Postoperatively, the patient's temperature climbed to 106° F., and the third day postoperatively, early signs of meningitis became apparent. Revision of the right mastoid was done and foul pus was released. There was a necrosis of the dura, but the sinus appeared normal. Cultures of this wound yielded a pure culture of *Staphylococcus aureus*. The patient died the next day with a temperature of 107° F., and

autopsy showed an acute leptomeningitis and pachymeningitis due to hemolytic streptococcus.

Serial sections of the petrous portion of the temporal bone showed, in the external canal, a few areas of fibrous tissue in which were many cavernous vascular spaces typical of capillary hemangioma. The remainder of the canal is partially filled with organizing exudate. The drum was destroyed anteriorly. Mastoid cells had been largely removed at operation. The petrous pyramid is non-pneumatic except for a few cells in the level of the eustachian tube. These show a mild chronic infection with many holes of cholesterol crystal shape. There is considerable hypertrophy of the mucous periosteum and considerable new bone formation about these cells. The marrow in the cavities in the immediate proximity of these cells is filled with myxomatous type of material and there is considerable new bone formation. Apparently the dense petrous pyramid observed in the roentgen films is due to chronic osteomyelitis of the petrous portion of the temporal bone. The left bone is normal. It is a relatively poorly pneumatic type of petrous pyramid.

Fig. 22. Case xxiv. E.B. (autopsy No. 11,863). Occipital projection showing fuzzy outline of the petrous ridge on the right (cf. Fig. 11).

Fig. 23. Case xxiv. E.B. (autopsy No. 11,863). Reversed Stenvers' position showing increased density in the petrous pyramid on the right. Compare Figure 22 and Figure 11.

Case xxiv. E. B. male, aged twenty-six (X-ray No. 121450. Unit No. 416695. Path. No. 11863).

Admitted to the clinic on May 4, 1934, complaining of deafness and discharge from the right ear of one week duration.

Films of the mastoids showed very slight haziness of the cells on the right as compared with those on the left.

He was again admitted to the hospital on May 11, 1934, because of persistent discharge and tinnitus over the mastoids. A simple right mastoidectomy on May 17, 1934, revealed a very pneumatic mastoid with a small amount of serous pus and granulation tissue throughout. There was considerable breaking down in the zygomatic region. Cultures from the right ear showed hemolytic *Staphylococcus aureus*.

Postoperatively, the patient developed an acute pharyngitis with some discharge from the paranasal sinuses on the left side, but this cleared. The patient was discharged with a dry canal and very slight serous discharge from a healthy looking posterior wound.

FIG. 24. Case XXIV. E.B. (autopsy No. 11,863). Reversed Stenvers' position showing the diploic petrosa on the normal side. Compare Figure 23.

Readmitted on June 20, 1934, because of vertigo and tinnitus, pain in the back of the eyes, especially on the right side. Films of the mastoids showed clouding of a small pneumatized area of the petrous pyramid. The patient improved with bed rest and it was felt that many of his complaints were quite definitely of a psychoneurotic nature.

Readmitted on July 9, 1934, for the removal of a large amount of lymphoid tissue in the nasopharynx. By August 23, 1934, the symptoms had become worse and he was readmitted on August 25, 1934, for a revision of his simple mastoidectomy. The mastoid process was partially filled with new bone, but no very serious pathology was encountered.

Readmitted on October 11, 1934, when a radical mastoidectomy was performed. The middle ear was found filled with granulation tissue, the malleus was intact, but the incus was not found. He was discharged on November 9, 1934, very much improved. A slight discharge continued from the posterior wound and this became worse two months later. By December 31, 1934, he was again complaining of pain in the right temporomandibular joint region and in the occiput. Irrigation of the sphenoids yielded nothing.

Readmitted on April 25, 1935, for further revision. The pain in the occipital region which sometimes radiated from the ear to the right eye was annoying, but never reached an unbearable level. Films in the oblique and mentovertical positions continued to show asymmetry in two petrous pyramids with a marked clouding in the right side.

On April 29, 1935, the mastoid was again opened. A large decompression was performed, the tegmen removed over the middle ear and the brain lifted. A curette was used to remove the surface of the petrous bone. No pus was found but a drain was inserted. On May 3, 1935, a partial facial paralysis on the right was noticed. This increased and the pain behind the eye and in the occipital region continued. There was a questionable external rectus paralysis. Profuse discharge continued from the canal. A new attempt was made to expose the portion of petrous pyramid from which the pus, which kept draining from the wound, must come. On June 13, 1935, the ridges of the petrous pyramid were followed to a depth of 2 inches without locating any pus pocket. By July 5, 1935, the facial paralysis disappeared, but the pain in the right face and right occipital region and right eye was terrific. On July 6, 1935, he developed signs of a generalized meningitis and on July 10, 1935, he died. Hemolytic streptococcus in spinal fluid.

Autopsy showed a diffuse meningitis and a chronic osteomyelitis of the petrous portion of the temporal bone below and behind the horizontal portion of the carotid artery. This portion of the bone had never been opened during the operations because the superior approach through the middle fossa was used. Now the transcarotid approach suggested by Ramadier would probably be used.

CASE XXV. J. B., male, aged forty-five (X-ray No. 75884. Unit No. 272103. Path. No. 10938).

Admitted to the Vanderbilt Clinic on October 31, 1930, with a history of frequent head colds and watery discharge from the right ear for sixteen months. There was a large perforation into the attic on this side. He had been treated for some time with alcohol and boric acid drops.

Films of the mastoids showed a bilateral sclerosing process, more marked on the right.

On March 30, 1932, he came in complaining of pain in the right side of the neck and right side of the head, as well as nausea and vomiting, chills and fever. There was a little tenderness over the mastoid. The patient gave a history of having an otitis media twenty years ago, with occasional exacerbations since. Three days before admission, the discharge which has been going on for the past few weeks ceased for about two or three hours, and then he developed severe pain in the right side of the head just lateral to the eye. This pain was dull and aching in character and quite severe. Some hours later, he awoke to find his pillow covered with blood and his ear has been discharging moderately ever since.

Physical examination showed a profuse foul discharge with a swollen tender canal. No mastoid tenderness. Films of the mastoid at this time showed a sclerosing process on the right, and a sclerotic pyramid on both sides.

Lumbar puncture at this time showed 3,600 cells and 90 per cent polymorphonuclears.

Radical mastoidectomy was performed and a large cholesteatoma was found, extending from the middle ear cavity along the dura from the horizontal semicircular canal to the sinodural angle. There was no free pus in the mastoid wound.

The patient went rapidly downhill after the operation, and the beginning of the second week he died suddenly.

At autopsy a chronic mastoiditis with a superimposed acute process was found, as well as a chronic osteomyelitis of the petrous portion of the bone. There was a large lunate abscess in the posterior portion of the right temporal and anterior two-thirds of the right occipital lobe. It had broken into the posterior horn of the lateral ventricle. Culture of the infected material showed *B. proteus* and hemolytic streptococcus

For Cases XXVI, XXVII, XXVIII, and XXIX see reference 5.[1]

SUMMARY

1. The word "petrositis" is used in a generic sense to include inflammation of the petrous portion of the temporal bone exclusive of the mastoid. This includes the perilabyrinthine as well as the antelabyrinthine regions, and inflammation of the non-pneumatized as well as the highly pneumatized bones.

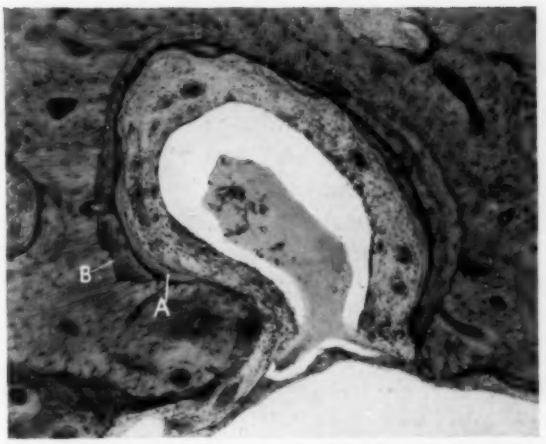

FIG. 25. Small air cell in the mastoid showing thickened mucoperiosteum, osteoid tissue, *A*, and new bone which was laid down by a previous infection, *B*. This shows how air cells are filled with new bone by repeated infections.

2. Roentgenographic changes are found in the petrosa with mild as well as with severe infections.

3. Some pneumatization is present in every petrous pyramid examined in our adult material. This pneumatization is often characterized by only a few peritubal cells or a few cells in the region of the middle ear, but they nevertheless are a part of the petrous pyramid and are a potential pathway for infection to the petrosa.

4. If the temporal bone is well pneumatized, the roentgenographic picture shows clouding of the pneumatized areas when compared with normal areas on the other side, and serial sections show edema of the mucoperiosteum and some exudate in the air spaces without much bone destruction or regrowth (Fig. 25). If the infection is severe in this type of bone, a decrease in density supervenes and sometimes a break in the bony cortex of the petrous pyramid is found. Microscopic sections show bone destruction similar to that found in the mastoid except that there is invariably more osteomyelitis surrounding the infected air cells than is usually possible in the mastoid.

5. If the temporal bone is not well pneumatized, inflammation in the petrous pyramid usually manifests itself roentgeno-

logically by an increased density. Serial sections show that there is first a fibrosis of whatever air cells are present, as well as fibrosis of the surrounding marrow cavities with regrowth of first osteoid tissue and then bone. Occasionally a low grade active osteomyelitis persists in these cases, and this may invade the cortex causing breaks in the bony outline which are apparent roentgenologically (Fig. 17).

6. Abscesses not apparent roentgenologically can be present in the petrous pyramid and eventually be the cause of death if drainage is not established (Fig. 12).

7. A series of 29 cases are reported which demonstrate the various manifestations of petrositis. These are divided into four groups according to their clinical and pathological characteristics.

CONCLUSIONS

1. There is usually some involvement of the petrosa in cases of mastoiditis.

2. Because of the nature of the architecture of the petrosa, clinical petrositis is perhaps always a combination of osteomyelitis and infection of air cells.

3. In the majority of the cases, increased density of the petrous bone roentgenographically is the rule rather than decreased density.

4. It is probable that every case of long-standing ear infection with continued drainage after radical mastoidectomy is due to deep-seated infection in the petrosa.

REFERENCES

1. AMBERG, E. Wittmaack's views concerning the normal and pathologic pneumatization of the temporal bone. *J. Michigan Med. Soc.*, 1922, *21*, 78–84.
2. BEZOLD, F. Die Corrosions-Anatomie des Ohres. Munich, 1882.
3. EAGLETON, W. P. Unlocking of the petrous pyramid for localized bulbar (pontile) meningitis secondary to suppuration of petrous apex. *Arch. Otolaryng.*, 1931, *13*, 386–422 (Case 2).
4. ECKERT-MÖBIUS, A. Vergleichend anatomische Untersuchungen und Pneumatisationslehre. *Acta oto-laryng.*, 1938, *26*, 115–127.
5. FOWLER, E. P., JR. Suppuration of the petrous tip. *J. Am. M. Ass.*, 1934, *102*, 1651–1655. Also: Symposium on petrositis. *Ann. Otolaryng.*, or *Tr. Am. Otolog. Soc.*, 1935.
6. GRADENIGO, G. Ueber circumscripte Leptomeningitis mit spinalen Symptomen und über Paralyse des N. abducens otitischen Ursprungs. *Arch. f. Ohrenheilk.*, 1904, *62*, 255–270.
7. GUILD, S. R. Certain fundamentals in regard to suppuration of the petrosal pyramid; normal and pathological anatomy of the petrous pyramid. *Ann. Otol., Rhin. & Laryng.*, 1935, *44*, 1011–1035.
8. KOPETZKY, S. J., and ALMOUR, R. Suppuration of the petrous pyramid. *Ann. Otol., Rhin. & Laryng.*, 1930, *39*, 996; 1931, *40*, 157; 396; 922.
9. MAYER, O. Die Pyramidenzelleneiterungen. *Ztschr. f. Hals-, Nasen- u. Ohrenh.*, 1937, *42*, 1–86.
10. MYERSON, M. C., RUBIN, H., and GILBERT, J. G. Anatomic studies of the petrous portion of the temporal bone. *Arch. Otolaryng.*, 1934, *20*, 195–210.
11. PROFANT, H. J. Gradenigo's syndrome, with consideration of "petrositis." *Arch. Otolaryng.*, 1931, *13*, 347–378.
12. RAMADIER, J. L'ostéite profonde du rocher. *Vie méd.*, 1933, *14*, 931–935; also *Médecine*, 1934, *15*, 64–71.
13. RÜEDI, L. Die Mittelohrraumentwicklung vom 5. Embryonalmonat bis zum 10. Lebensjahr. *Acta otol-laryng.*, Suppl. 22, 1937, pp. 1–132.
14. SIEBENMANN, F. Mittelohr und Labyrinth. In: Bardeleben, K. Handbuch der Anatomie des Menschen. G. Fischer, Jena, 1897, Vol. 5, Abt. 2.
15. TAYLOR, H. K. Roentgen findings in suppuration of the petrous apex. *Ann. Otol., Rhin. & Laryng.*, 1931, *40*, 367–395.
16. TAYLOR, H. K. Suppuration in the pneumatic antelabyrinthine portion of the petrous pyramid. *New York State J. Med.*, 1937, *37*, 231–235.
17. WITTMAACK, K. Ueber die normale und die pathologische Pneumatisation des Schläfenbeines. G. Fischer, Jena, 1918.

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OBSERVATIONS ON THE PROCESS OF OSSIFICATION IN THE FORMATION OF PERSISTENT ENLARGED PARIETAL FORAMINA*

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A LITTLE over two years ago, we[1] reported a study of two families in a number of whose members, distributed in four generations, there were present markedly enlarged parietal foramina. The older literature, dating back in fact to Lancisi in 1707, revealed a number of records of skulls having parietal foramina far larger than the usual millimeter-sized foramina which indeed are often absent. The literature also contained a few reports of the discovery of the anomaly during life and four reports of its occurrence in more than one member of a family, Goldsmith[2] finding evidence of the anomaly in 16 of 56 members of five generations of a family named Catlin. Although the literature contained a few speculations concerning the relation of the anomaly to normal skull development, there were no available data on this point. References to the literature are given in our earlier paper.

The second of the families which we studied was brought to our attention by Dr. J. W. Post and in this negro family, there happened to be two young children, both of whom exhibited abnormal ossification of the skull which gave promise of developing into persistent enlarged parietal foramina similar to those present in adult members of the family. An opportunity was thus offered for observing the process of ossification by repeated roentgenograms of these two children. These observations are here presented.

The normal ossification of the parietal bone commences in a single center at the end of the second fetal month. As the bones of the skull develop, there are six places where well-defined fontanelles exist. These are situated at the four angles of the parietal bones, two in the median line and two laterally on each side. In addition, there is present during fetal life in each parietal an interval between the radiating lines of newly formed bone along which ossification of the parietal progresses. This space is named the sagittal fontanelle. As the development of the parietal advances the sagittal fontanelle is encroached upon until, as a rule, about the seventh month of fetal life the fontanelle as such has disappeared and only the two minute parietal foramina remain open. Even in skulls which become wholly normal this process may be delayed and the sagittal fontanelle remain open until birth. The hereditary anomaly which we are discussing is due to an even greater delay and a failure of completion of the

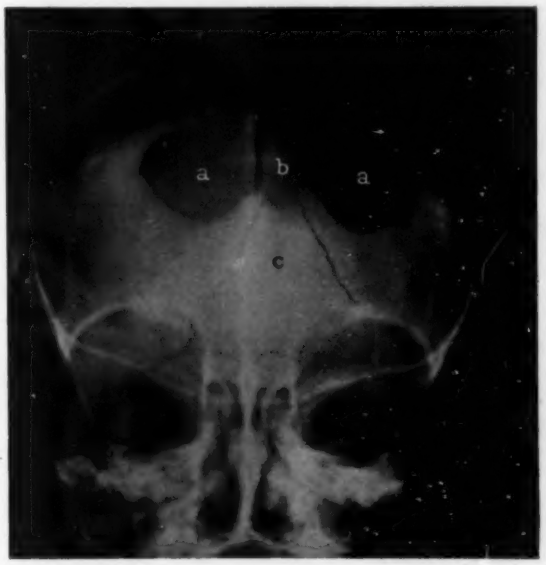

FIG. 1. Case 1. Very large merged parietal foramina in a child two years of age. Parietal foramina at *a*. They merge at *b*. The inca bone which is a normal variant is seen at *c*.

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Fig. 2. Case 1. Enlarged parietal foramina. Same case as Figure 1. Examination sixteen months later—ossification of the bone has progressed.

ossification of this region of the parietal bones.

At the time of our earlier report, the elder of the two children was two years of age. The roentgenogram of her skull, Figure 13 in the earlier paper, is here reproduced (Fig. 1) in order to compare it with one taken recently at the age of five and one-half years. At the age of two years the roentgenogram revealed a very large merged defect into which ossification was extending somewhat irregularly. In this skull, there is also present the not uncommon anomaly called by some the "inca bone."

In Figures 2 and 3 can be seen what has taken place in three years. Two very large openings persist and present the appearance which is characteristic of this anomaly. Of course, in this child it is possible that ossification will continue and will reduce the size of one or both of these huge parietal foramina. However, there is no certainty of this for many adults who exhibit this anomaly have foramina on one or both sides which are as large as those shown in this child.

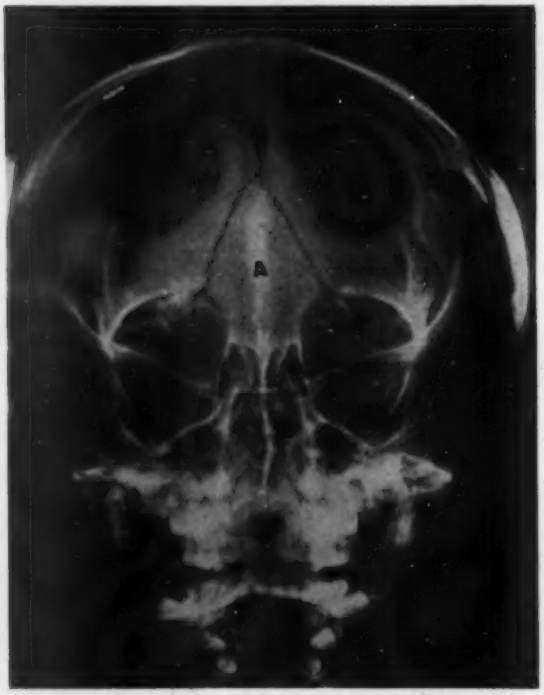

Fig. 3. Case 1. Enlarged parietal foramina. Same case as Figure 1. Examination three years after the first examination. The inca bone is still quite evident at *A*.

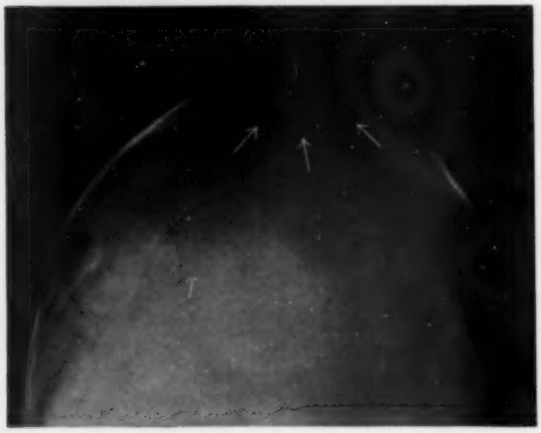

Fig. 4. Case 11. Large unossified area in the region of the posterior sagittal fontanelle in an infant six months of age.

The younger of the two children was only six months of age when the first roentgenogram was taken. At that age the sagittal fontanelle should have long since closed, but here we see (Fig. 4) a large circular space still wholly uninvaded by ossification. One month later (Fig. 5) ossification can be seen spreading mesially in an ir-

Fig. 5. Case II. Large unossified area in the region of the posterior sagittal fontanelle, female, aged seven months. There has been some ossification since the previous examination.

Fig. 7. Case II. Ossification progressing. On one side at *a*, the bone has almost ossified to the extent of forming a parietal foramen.

regular fashion. After six more months, at the age of about a year and one month, the advancing ossification has progressed considerably (Fig. 6). At two years of age the unossified spaces of the future parietal foramina were beginning to take form (Fig. 7).

Four months later (Fig. 8), one parietal foramen is surrounded by bone and the process of ossification is beginning to outline the other.

At the age of three years (Fig. 9), both

Fig. 6. Case II. Large unossified area still present. The parietal foramina are not evident as yet.

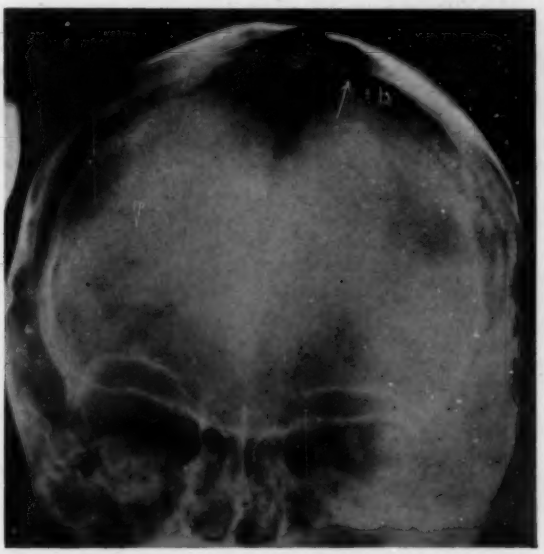

Fig. 8. Case II. The parietal foramina are now very clearly visualized at *a* and *b*—female, aged two years, four months.

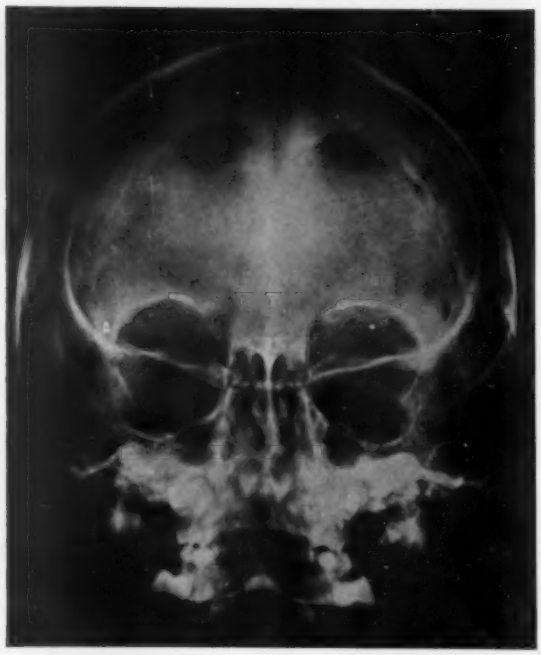

FIG. 9. Case 11. Enlarged parietal foramina in a child three years of age. This child is the sister of the other child illustrated in Figure 3.

foramina are well surrounded by bone and are of about the size that persists throughout life in certain of these individuals—whether in this child the foramina will become smaller cannot be told at this time.

From these roentgenograms one probably obtains an idea of what normally goes on during fetal life, but which in certain individuals of certain predisposed families is delayed and is never completed.

As one reviews these films and sees the developmental process reduce the large single area of the sagittal fontanelle to several irregularly shaped spaces, it is realized that almost any picture may result. In the normal, the process of ossification goes on, as we have said, until there usually remains a pin-sized foramina on each side through which an emissary vein passes. Often this foramen is absent, and in still other persons it may be double. In families exhibiting the congenital hereditary anomaly of persistent enlarged parietal foramina, the process of ossification is markedly delayed, does not go on to the normal conclusion and the final state is very variable. Sometimes both foramina remain large, sometimes only one. Sometimes in such families there are individuals with foramina larger than normal but not large enough to be discovered except by roentgenogram. Apparently this anomaly may occur in even more bizarre forms; in a roentgenogram of a skull sent by Dr. Stanley Wilson to Dr. M. C. Sosman, there are three distinct foramina each about 1 inch in length. There is no good reason to suppose that a great many variations will not be found as more of these individuals are studied by roentgenograms.

Probably this condition is far commoner than was formerly thought, for in pre-roentgen times only those instances were recognized during life in which the foramina were large enough to be felt. Also little attention has been given to this condition because of its failure to cause symptoms or ill health. It chief interest rests on its hereditary occurrence and the possibilities of misdiagnosis in the roentgenogram. This second report on this subject is justified by the light which the serial roentgenograms throw on the process of normal ossification of the parietal and on its abnormality in individuals who have inherited this developmental anomaly.

REFERENCES

1. PEPPER, O. H. P., and PENDERGRASS, E. P. Hereditary occurrence of enlarged parietal foramina; their diagnostic importance. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *35*, 1–8.

2. GOLDSMITH, W. M. The Catlin mark; the inheritance of an unusual opening in the parietal bones. *J. Hered.*, 1922, *13*, 69–71.

Vol. 41, No. 3

DEVELOPMENTAL SKULL ANOMALIES*

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IT IS the purpose of this paper to describe and to illustrate with case reports anomalies of the skull that are the result of disturbances in development.

We present a very brief review of the anatomy, embryology, pathogenesis and the various skull indices and measurements generally employed in the study of skull abnormalities.

ANATOMY AND EMBRYOLOGY

The skull bones belong to the type of so-called flat bones, possessing diploe filled with medullary tissue lying between an external and an internal shell of compact bone. During embryonic development, the skull exhibits in part, a cartilaginous and in part, a primitive membranaceous or connective tissue shell. The skull base and the facial skeleton are originally cartilaginous and the vault membranaceous. Later, a great number of bone areas appear in the cartilaginous part as well as in the membranous portion, namely, several points of ossification for each piece of the skull. With the growth of these areas of bone, the cartilaginous and the membranous ground substances disappear more and more, so that finally only narrow bands of cartilage (base) and connective tissue (vault) are left between the pieces of bone. These correspond to the so-called sutures of the skull.

After the first years of extrauterine life, practically all the basal sutures except the spheno-occipital have ossified. The sutures of the vault, on the other hand, remain open for a long time, Normally, they do not disappear for years after the conclusion of the period of growth of the rest of the body.

DISTURBANCES IN DEVELOPMENT

Disturbances of skull development result from the fact that the growth may be abnormally slow or abnormally rapid, that it terminates before or after the normal time, and that ossification of the cartilaginous and the connective tissue skull shell and the sutures occurs prematurely or is delayed.

MEASUREMENTS AND INDICES EMPLOYED IN PHYSICAL ANTHROPOLOGY

Cranial Capacity. The normal limits for capacity are those holding between 1,350 and 1,450 cc. (mesocephalic). Below 1,350 cc. capacity we have microcephaly, while above 1,450 cc. we have megalocephaly.

Differences in Shape. The relation between the breadth and length is expressed by the cephalic index. This is obtained by dividing the maximum breadth times one hundred by the maximum length. The maximum breadth is the bi-asterionic measurement and the maximum length is the distance between the nasion and the external occipital protuberance. The normal cephalic index is 75–80. The relation between the height and the length is expressed by the vertical index which is obtained by dividing the height times one hundred by the length. The height is the distance between the basion and the bregma. The normal is between 72–77.

Horizontal Circumference. This is measured around a plane cutting the glabella anteriorly and the maximum occipital point posteriorly and normally ranges from 45 to 55 cm.

Facial Angle. This is obtained by a line from the root of the nose to the middle point of the alveolar process of the upper jaw, and the other leg by the line from the last named point to the anterior edge of the foramen magnum. The skull with a smaller facial angle is designated as prognathic in contradistinction to a normal (orthognathic) skull.

* From the Department of Radiology of Sydenham Hospital.

Sphenoid Angle. The angle between the line from the foremost point of the foramen magnum to the center of the sella turcica and from this point to the root of the nose is called the sphenoid angle. The normal is 134 degrees. Its size is a criterion for the fundamental shape of the skull base. In abnormal obtuseness of the sphenoid angle there exists a flattening of the basal angularity (platybasia); in abnormal smallness of the angle there is present a pathologic kyphosis of the skull base.

Schüller divides developmental disturbances of the skull into the following groups:

1. Malformations, such as Lückenschädel, anencephaly, and trigonocephaly.
2. Changes in the skull content, as in microcephalus and in hydrocephalus.
3. Craniostenosis or premature suture synostosis.
4. Defects due to external factors, such as those caused by pressure or traction from spinal defects or from anomalies of the soft tissues.
5. Those due to systemic disease such as those found in rickets, cretinism, mongolism, and in dwarfism. Here the changes form part of a generalized process where the growth is usually delayed.

1. MALFORMATIONS

(a) *Lückenschädel Malformation.* By this term is understood a skull anomaly in which the ossification of the cranial vault (having a membranaceous or connective tissue origin) is far below the normal. Between the ossified portions of the vault there are portions which remain membranaceous resulting in extensive bone defects.

(b) *Anencephaly.* By this term is meant an imperfectly developed head from which a large part of the calvarium and the brain is lacking. It really is an absence of the cranial vault with rudimentary development of the brain and is caused by malformation of that portion of the skull developing from membraneous pre-osseous tissue.

2. CHANGES IN SKULL CONTENT

The most common type in this group is hydrocephalus (capacity over 1,700 cc.) which is an accumulation of abnormal quantities of cerebrospinal fluid causing the head to approximate the dimensions of a sphere.

If, for any reason, the balance is restored between the internal and the external meningeal fluid, ossification of the fontanels and thickening of the cranial wall occur.

Bone islands frequently form within these membranaceous areas, and ossification develops from these. If these bone islands maintain their individuality, they become the so-called supernumerary or wormian bones. These are also found in other types of skulls of abnormal size which also remain membranaceous an abnormally long time. The wormian bones, in addition to this, have an anthropologic interest because they appear in certain animals and are apparently also met with regularly in certain human races.

3. CRANIOSTENOSIS

The premature synostosis of sutures means that one or more sutures or fissures of the skull ossify before their usual normal time. Synostosis may be present at the time of birth, but usually it makes its appearance at a later period. The cause is unknown. Gansslen and his coworkers in 1925 emphasized the frequency of premature synostosis of the skull in chronic hemolytic icterus due to the microcyte, and Mikulowski in 1928 described a severe oxycephalic deformity in a case of chronic hemolytic icterus. The irregularity in growth produced by premature synostosis appears as a result of the fact that the skull is not able to increase in size in the direction perpendicular to the course of the obliterated suture. In most cases, this limitation is compensated for by the fact that the skull develops in the other direction, which results in a striking anomaly. The skull growth does not keep pace with the brain and there results a disproportion between the skull contents and the cranial capacity.

In consideration of the fact that the skull is too small for its contents, one speaks of craniostenosis. The disproportion is expressed anatomically by the fact that the inner surface of the skull is eroded corresponding to the tops of the brain convolutions thereby causing a thinning. There are three types of craniostenosis:

(a) *Turricephaly* (most frequent). This is the short, broad and normally high skull. The vertex may be broad or pointed (oxycephaly). The bregma is bulging. The sutures are prematurely synostosed. The convolutional impressions are prominent and the vault is thinned. There is a basal kyphosis. There may be optic disturbances with distortion of the optic foramina and the superior orbital fissures. There may be other developmental disturbances elsewhere in the body.

(b) *Scaphocephaly*. This is an abnormally long and narrow skull due to premature closure of the sagittal suture.

(c) *Plagiocephaly*. Here the head is slanting due to asymmetrical synostosis of the sutures.

CASE REPORTS

Case 1. J. M., aged ten, colored male, admitted to Sydenham Hospital with a history of severe headache and some dizziness starting six hours prior to admission. There was no vomiting, nausea nor convulsions. The patient has had similar attacks before, especially two and one-half years ago when the severity of the episode caused him to be hospitalized.

Fig. 1. Case 1. Craniostenosis with partial Lückenschädel malformation.

Fig. 2. Case 11. Anencephalus *in utero*.

Physical Examination. Patient lies in bed with both legs flexed at the knees and hips. The head is hyperextended and there is some nuchal rigidity. The patient is semistuporous and reacts very sluggishly to interrogation. There is pallor of the optic discs, but sight is apparently unimpaired. There is no exophthalmos. The Wassermann reaction is negative. The remaining laboratory data are negative except for a mild secondary anemia.

Roentgen Examination. There is generalized thinning of the vault with prominence of the convolutional markings. The sella turcica is slightly ballooned and the dorsum is thinned. The sutures are synostosed and the middle fossa is depressed, producing a basal kyphosis (the sphenoid angle being 100°). The vertex is high. There are unossified membranous areas at the frontoparietal regions.

Comment. This case exemplifies a malformation probably due to premature synostosis of the vault sutures, with a consequent increase of the intracranial pressure, resulting in a condition of craniostenosis of

Fig. 3. Specimen of Case II.

the turricephalic type. The unusual feature of this case is the presence of unossified areas of membranous bone in the frontoparietal regions producing a partial "Lückenschädel" formation. This case is also illustrative of a point recently emphasized by Sosman, i.e., "the greatest source of error is not in missing a pituitary adenoma, but in misinterpreting a sella deformed from general pressure as an adenoma." The disturbance in the sella in this case is due to the craniostenosis and not to any intrasellar lesion.

Case II. B. P., aged twenty-seven, white female, admitted to Sydenham Hospital with a history of being eight weeks overdue in this, her first pregnancy. History is essentially negative.

Physical examination revealed an ample pelvis and a viable fetus in the left occipito-anterior position.

Roentgen examination revealed an anencephalic monster. The calvarium was malformed and compressed. The base of the skull was apparently normal.

Subsequent History. After two unsuccessful attempts at induction of labor, an embryotomy was performed and a 15 pound male anencephalic monster delivered. The patient was given repeated blood transfusions and eventually discharged as recovered.

Comment. This case serves to emphasize the importance of the routine roentgen examination in pregnancy, the lack of which imperilled unnecessarily the life of the patient in the above case. Its special importance lies in the fact that the imperfectly developed head is not an efficient dilating agent and its early recognition reduces complications later on.

Case III. The following case report serves to illustrate the value of the pre-term recognition of anencephalus by roentgenography, thereby permitting of a simple induced delivery free from complications.

A female, aged twenty-five, admitted to Sydenham Hospital in her first pregnancy. She was due to deliver in four weeks. She was admitted for vaginal bleeding.

Physical Examination. The uterus was small for the length of the pregnancy. The pelvis was ample and the fetus viable.

Roentgen examination revealed an anence-

Fig. 4. Case III. Anencephalus *in utero*.

phalic monstrosity with underdevelopment of the calvarium. The skull base was normally developed.

Subsequent History. Labor was induced and a living fetus delivered which lived for thirteen hours. The mother made an uneventful recovery.

Additional Comment on Cases II and III. It is interesting to note that besides the presence of the anencephalus, the fetus in Case II exhibited hypoplasia of the adrenals and the fetus in Case III showed necrotic foci in the same glands.

In both cases of anencephalus, there was apparently normal development of that portion of the skull (base) arising from cartilage and non-development of that portion developing from membranous tissue (vault). The clavicles, also having a membranous origin, were normally developed in both cases.

Case IV. F. T., aged five, male. Referred for roentgen examination of the skull at Gouverneur Hospital with a clinical diagnosis of a possible hypothyroidism because the patient was small for his chronological age. There are no visual disturbances and the patient has no symptoms referable to his skull.

Fig. 5. Specimen of Case III.

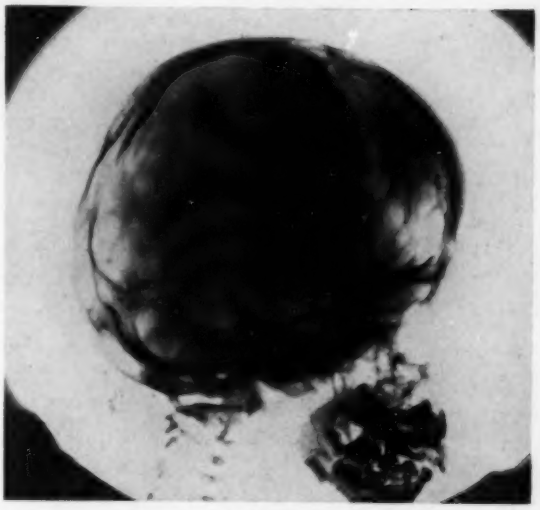

Fig. 6. Simple turricephaly, Case IV.

Roentgen Examination. There is thinning of the vault with prominence of the markings. There is premature synostosis of the vault sutures with an increase in the vertical index, the skull being short, broad and abnormally high. There is a basal kyphosis.

Comment. This case is illustrative of a simple turricephalus with apparently no subjective symptoms at the age of five. However, the roentgen evidence of an increased intracranial pressure signifies the early expectancy of a series of subjective complaints.

Case V. This case is very similar to Case IV except for the type of turricephalus. Here the only variation is the pointed vertex and is therefore referred to as the oxycephalic type. There is shortening and deepening of the fossae, the course of the alae minor is steep and there is shortening of the superior orbital fissures.

Case VI. This case is illustrative of a symptomless scaphocephaly in an adult. This malformation is due to a premature synostosis of the sagittal suture which results in a long scaphoid shape of the skull. There is no increase in the intracranial pressure and the skull shows thickening. There is a platybasia present, the sphenoid angle being larger than normal. In the

Fig. 7. Case vi. Scaphocephaly.

skull base the narrowness and the great length of the fossae, as well as the diminution of the angle formed by the two pyramids, are very striking.

Fig. 8. Case vii. Wormian bones.

Comment. Since there can occur a sufficient compensation in the sutures remaining open, the signs of a disproportion between brain and skull are usually much less marked, corresponding to which the clinical symptoms in such cases are usually minor in character, or even absent as in our case.

Case vii. S. K., male, aged nine months. History of convulsions for the past five months. For the past three months, the patient has had one convulsion a day. The patient shows retarded mentality and there are no teeth present at the age of nine months.

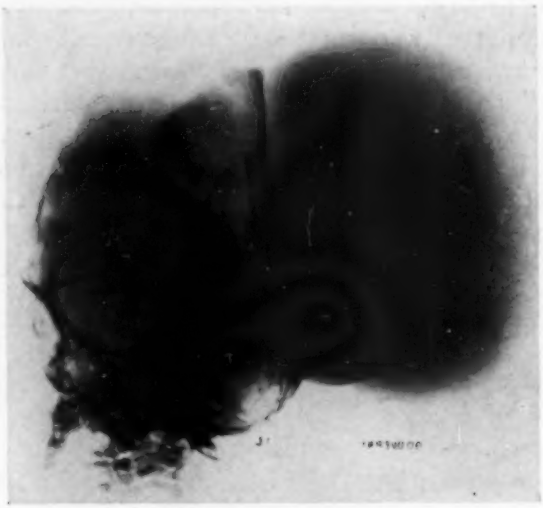

Fig. 9. Case viii. Congenital hydrocephalus with a very large meningocele.

Roentgen Examination. Reveals the presence of numerous wormian bones along the vault sutures.

Comment. Although wormian bones are apparently met with regularly in certain human races, their presence in this case supplies an etiology for the oft-repeated convulsions. It is not possible to clearly explain how these individual bone islands are responsible except to suggest that their edges may somehow bear a causal relationship, possibly by irritation. The delayed appearance of the teeth speaks for a systemic disturbing factor as yet unrecognized in this particular child.

Case VIII. L. C., male, aged five and one-half years, admitted to Gouverneur Hospital with the following history: At birth there was congenital hydrocephalus. Shortly after, there appeared a mass over the left parietal bone which has gradually increased in size along with the hydrocephalus. One month ago, this patient fell, striking the left eye. The mass on the left side then rapidly enlarged with marked exophthalmos and divergence of the eyes, together with marked impairment of audition and vision. The patient vomits, has severe headaches and has lost the power to stand up.

Physical examination reveals a spherical enlargement of the skull, characteristic of hydrocephalus and the added presence of a large cystic mass over the left parietal area which is capable of transmitting light.

Roentgen examination reveals a markedly enlarged spherical skull of the hydrocephalic type. The vault bones are thinned and there is a defect in the left parietal bone where a mass is continuous with the skull. The mass contains no bony elements and is of fluid density.

Necropsy Report. Congenital hydrocephalus with meningocele.

Comment. This case is illustrative of a disturbance in development of the skull as a result of changes in the skull content, with the added feature of the extrusion of a meningeal sac containing fluid through an unossified or eroded area in the left parietal bone.

CONCLUSIONS

The pathogenesis of the various deformities resulting from disturbances in the normal development of the skull have been described and illustrated with case reports. They show as a common characteristic variations from the normal in size and shape, the abnormalities in skull structure being insignificant. The skull is either too small or too large, asymmetrical, disproportionate or completely deformed.

The roentgenographic presentation of the deformities of the skull, exclusive of contrast methods, serves as a valuable supplement to the older methods of measurement. It permits a study of the size and shape, which is especially valuable if repeated examinations are made for progress of the disease. It visualizes the shape and the details of the skull base and the sella turcica. It gives positive information relative to the appearance of the sutures (obliteration, widening and the presence of supernumerary bones). It permits the determination of the thickness and the density of the bone in general and the variation, if present, of the two halves of the skull. It permits a study of the inner surface of the skull as to the presence or absence of convolutional atrophy. In cases of cerebral hernia it visualizes the portal of exit. It demonstrates the thickness of the soft tissue and offers accordingly the possibility of correcting the capacity of the skull as obtained by cephalometric methods.

Finally, the diagnosis of fetal deformity before the onset of labor is very desirable because dystocia, as in hydrocephalus, may be foreseen; and because the considerations of fetal survival, as in anencephaly, may be eliminated from the principles of the labor management.

REFERENCES

1. Cunningham. Textbook of Anatomy. William Wood & Co., New York, 1923.
2. Schüller, A. Roentgen Diagnosis of Diseases of the Head. Translated by F. F. Stocking. C. V. Mosby & Co., St. Louis, 1918.
3. Sosman, M. C. Reliability of roentgenographic signs of intracranial tumor. Am. J. Roentgenol. & Rad. Therapy, 1936, *36*, 737–743.
4. Waters, C. A., and Kaplan, I. I. Year Book of Radiology. Year Book Publishers, Inc., Chicago 1935, p. 274.
5. Gänsslen, M., Zipperlen, E., and Schüz, E. Die hämolytische Konstitution. *Deutsches Arch f. klin. Med.*, 1925, *146*, 1–46.
6. Mikulowski, V. Oxycéphalie dans l'ictère hémolytique. *Arch. de méd. d. enf.*, 1928, *31*, 31–36.

ROENTGENOLOGIC AND GASTROSCOPIC STUDIES IN CHRONIC GASTRITIS AND PEPTIC ULCER*

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THIS report is a presentation of the roentgenologic and gastroscopic observations in chronic gastritis and peptic ulcer. Since the technique of gastroscopy has been thoroughly covered in recent literature, there will be no discussion of that subject. Only those points related to the roentgenologic findings will be mentioned.

The value of the roentgenologic gastrointestinal examination, especially the method of examining the barium-filled stomach and bulb, is well established. Correlation of the gastroscopic with the roentgenologic findings necessitates the use of the mucosal relief and compression techniques, first developed by v. Elischer and later by Forssell, Berg, Åkerlund, Rendich, Chaoul, and others. Lesions not seen by the older filled-stomach procedure may occasionally be demonstrated by these newer methods. Particularly is this true of duodenal ulcer crater, ulcer of the posterior gastric wall, and gastritis. On the other hand, some gastric ulcers that show well in the filled stomach cannot be seen by the mucosal relief method. Interpretation of mucosal relief films requires considerable experience. The method is by no means foolproof and should always be accompanied by an examination of the filled stomach.

PATHOLOGY OF GASTRITIS

The once popular diagnosis of gastritis fell almost into oblivion in the early part of the present century in spite of the excellent observations of Beaumont on Alexis St. Martin and the pathological observations of Jones, Fox, Fenwick and Ewald in the middle and latter portions of the nineteenth century. The development of the formalin method to stop post-mortem autolysis by Knud Faber and C. E. Block in 1898 paved the road to adequate microscopic studies of the gastrointestinal mucosa. It is the work of Faber, Block, Lubarsch and that of later investigators, principally Konjetzny and his collaborators, Kalima and Puhl, that has again established gastritis as a pathological entity.

Faber and Block, taking the histologic appearance of the mucosa in normal newborn infants as normal, noted in a high percentage of adults definite mucosal changes of one type or another which they referred to loosely as gastritis.

Most pathologists agree that two general classes of chronic gastritis exist, the hypertrophic and the atrophic. In the advanced stages identification is easy but borderline cases are debatable. The normal histologic picture of the gastric mucosa is not yet definitely established. Possibly not all mucosal changes are inflammatory. Some may result from functionally deranged glandular mechanism, as suggested by Faber and Block.

CLINICAL DIAGNOSIS OF GASTRITIS

There have been sporadic attempts in the past to diagnose gastritis roentgenologically and numerous diagnostic signs have been described such as hyperperistalsis, excess secretion or gastric fluid, thin folds, thick folds, tortuous folds, straight folds, many folds, few folds. Berg, Henning, Gutzeit, Kuhlmann, and others, believe, however, that any of these findings may be encountered in presumably normal stomachs. Now with the development of a satisfactory gastroscope and the training of competent gastroscopists, medical interest in gastritis is increasing.

* From the Division of Roentgenology and the Department of Medicine of the University of Chicago. Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept., 13–17, 1937.

It is difficult to collect any large amount of autopsy material on patients who have been gastroscoped during life and even those cases that are available are of little use because of post-mortem changes in the mucosa. These changes are caused principally by cessation of circulation and are inevitable even though fixation is done before autolysis occurs. The gastroscopist, therefore, bases his conception of the normal mucosa not on histologic studies but on gastroscopic studies in large numbers of healthy individuals of various ages.

CLASSIFICATION

Schindler has classified chronic gastritis into the superficial, atrophic and hypertrophic types. Superficial gastritis may be an early phase of atrophic gastritis as the conditions frequently exist together. At times transition of the superficial into the atrophic form seems to occur. Schindler includes in a separate group instances of small hemorrhages and pigment spots occurring in otherwise normal mucosa. He believes that a stomach containing these non-inflammatory lesions is prone to develop ulcers. It is on Schindler's classification of the gastroscopic findings that we have based our roentgenologic studies.

SUPERFICIAL GASTRITIS

In superficial gastritis red, apparently hyperemic, spots of various sizes and occasional small erosions are associated with layers of mucus. Since the hemorrhagic spots do not cause gross mucosal defects and since erosions are very shallow and are usually not surrounded by elevated hyperemic or edematous margins, one cannot expect to demonstrate them roentgenologically (Fig. 1). Mucus often causes a mottling of the barium pattern, but since other types of gastric secretion and swallowed saliva may cause similar appearances in normal stomachs the sign is of little diagnostic value (Berg) (Fig. 2).

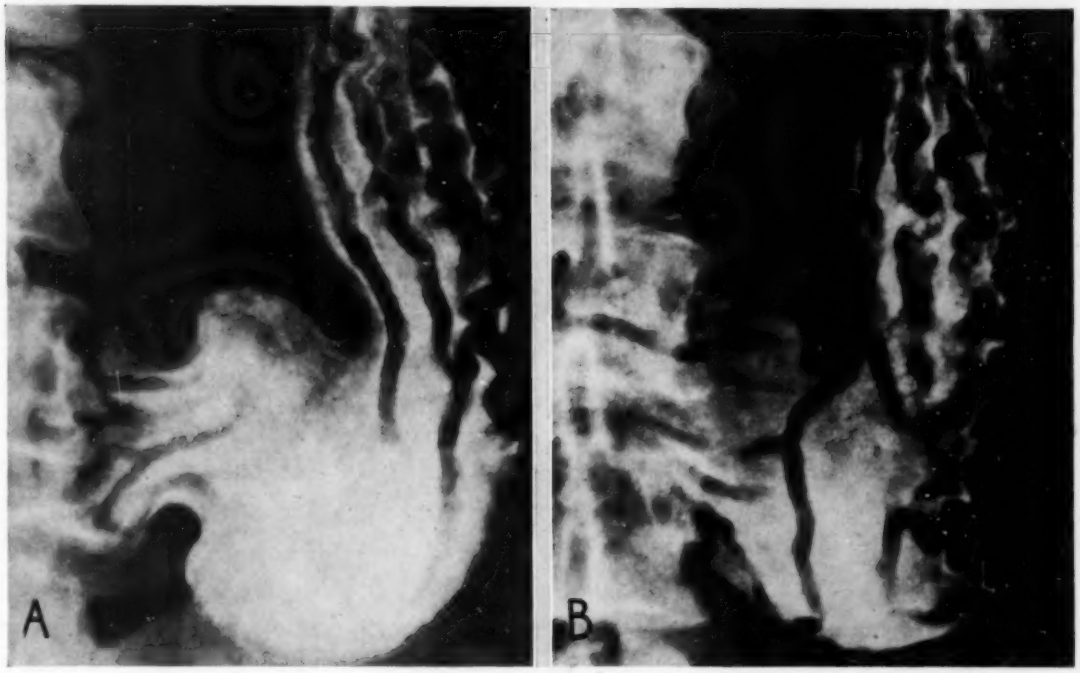

Fig. 1. At gastroscopy superficial gastritis was seen in *A*, and normal mucosa in *B*. Roentgenologically the cases appear quite similar.

ATROPHIC GASTRITIS

In atrophic gastritis grayish-green spots are seen gastroscopically. If atrophy is complete and the mucosa is quite thin, the

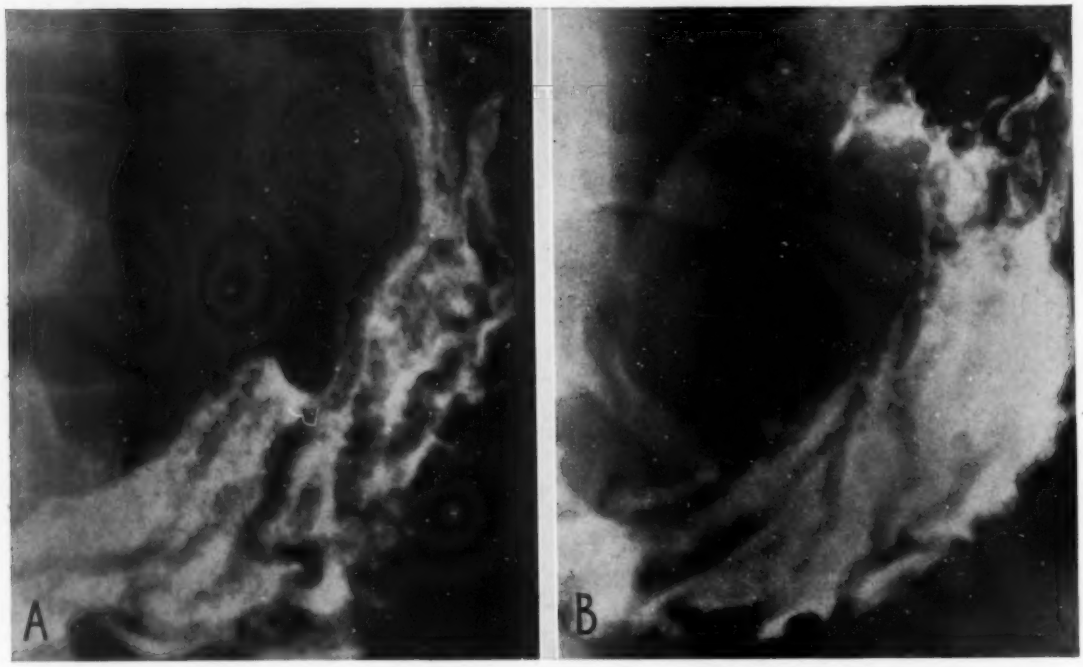

FIG. 2. *A*, the fine mottling of the barium shadow, presumably from secretion, is said by some authors to be evidence of gastritis. Gastroscopically, the mucosa was normal. *B*, there is very little mottling of the contrast shadow. Superficial gastritis was seen at the gastroscopic examination.

branching blood vessels of the submucosa can be seen through it. Although very thin folds which can easily be obliterated by slight pressure are often seen roentgenologically, the finding is by no means diagnostic.

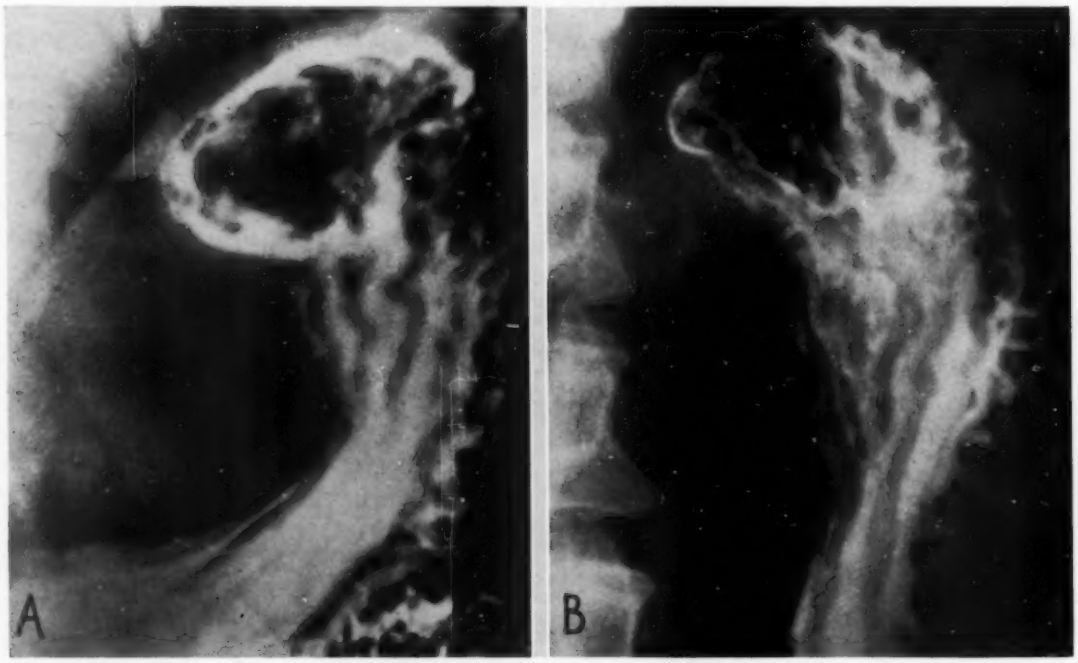

FIG. 3. Although gastroscopy revealed marked atrophic gastritis in *A* and normal mucosa in *B*, no detectable difference was found at roentgen examination.

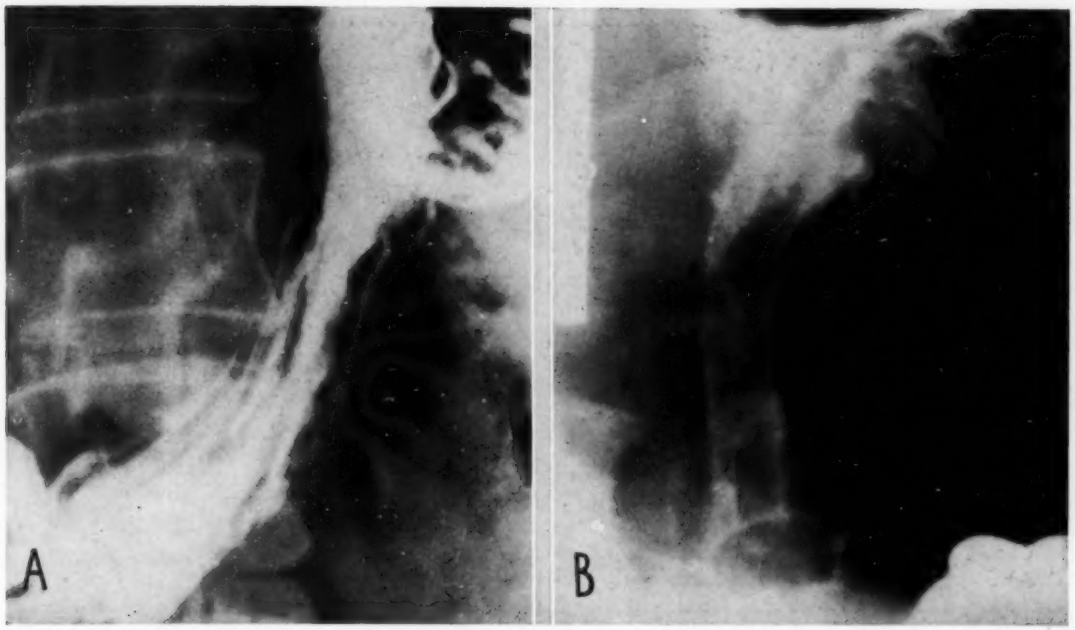

Fig. 4. *A*, thin folds in marked atrophic gastritis. *B*, thick folds in marked atrophic gastritis. Although the shadow of the compression block with its opaque center is seen, compression was not applied at the time the roentgenogram was taken.

Thin folds are sometimes seen in debilitated and dehydrated patients, a finding explained by the autoplastic phenomenon described by Forssell. Henning and Gutzeit found that stomachs which are normal gastroscopically may present similar thin, pliable folds roentgenologically (Fig. 3). They, as well as Berg and Pape, noted also that in marked atrophy large folds may be seen roentgenologically (Fig. 4). Duval and his coworkers described vasculo-connective tissue hypertrophy associated with thinned mucosa. Evidently, the size of the mucosal folds is not always determined solely by the thickness of the mucosa.

HYPERTROPHIC GASTRITIS

In the hypertrophic forms the gastroscopist sees a swollen, velvet-like mucosa which is often verrucous, nodular, with

Fig. 5. Gastroscopic appearance of hypertrophic gastritis. *A*, many nodules are seen between the folds. A yellow ulceration, surrounded by a red halo, lies on the central fold. *B*, large and small nodules have replaced the normal mucosa. Two small erosions lie below the center of the picture. Usually this type of gastritis is readily differentiated from carcinoma by the gastroscopist (see Fig. 9, *B*). *C*, segmented, caterpillar-like folds are sometimes seen in hypertropic gastritis. *D*, hypertrophic ulcerative antral gastritis. The large, stiffened, musculus sphincter antri contains one large ulceration. An ulceration on the edge of the pylorus and a bleeding ulceration on the posterior wall of the antrum are also present.

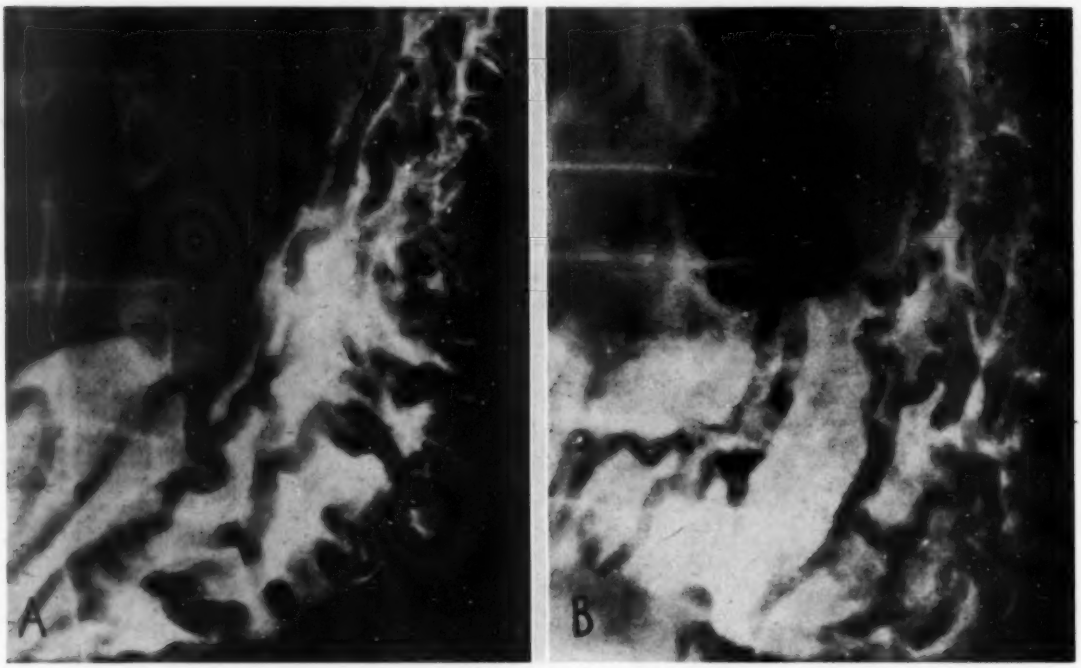

Fig. 6. *A*, mucosal pattern in a severe hypertrophic, ulcerating hemorrhagic gastritis. The folds were very pliable. *B*, mucosal pattern in a stomach with normal mucosa. Both cases appeared similar at roentgen examination.

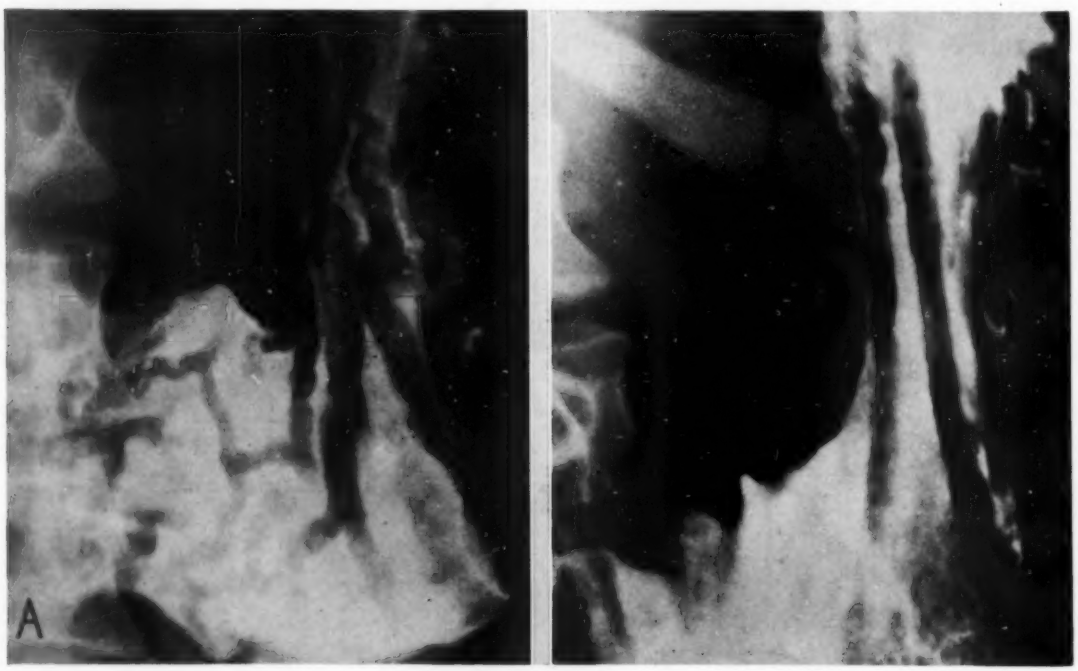

Fig. 7. *A*, the two folds in the region of the incisura angularis have a cross-hatched appearance. At gastroscopy two segmented folds were observed in this location. *B*, the two folds that extend the entire length of the body have a cross-hatched pattern. Although segmented folds were observed on the posterior wall of the body at gastroscopy, the extent was not that indicated on the roentgenogram. It may be that the pattern in this case was caused by secretion.

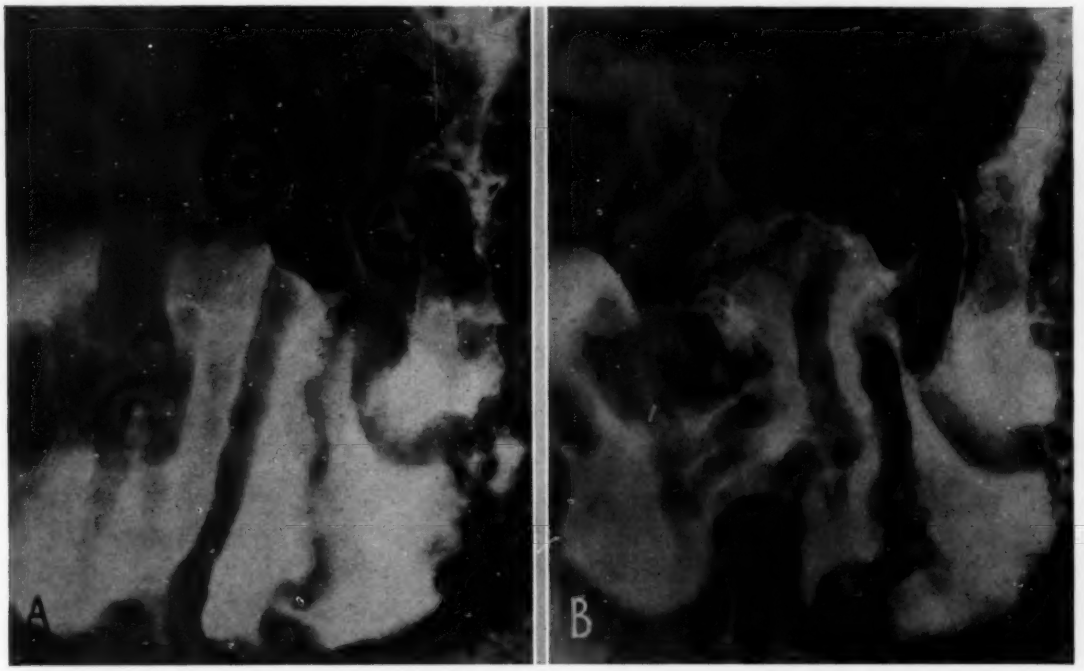

FIG. 8. Large stiffened folds in hypertrophic gastritis. Hypertrophic nodules seen at gastroscopy are indicated along the lesser curvature of the antrum, between the peristaltic waves in *B*. Deep peristaltic waves, indicated by comparing the two views, helped to differentiate the condition from submucosal infiltrating carcinoma. The patient had a duodenal ulcer.

segmented folds and very shallow ulcerations. This swelling may or may not be associated with changes in fold size. The nodules in the early stages lie usually in the valleys but in the later stages the crests are involved as well (Fig. 5, *A* and *B*).

The roentgenologic findings in hypertrophic gastritis are rarely diagnostic. Sometimes the roentgenologic appearance may be normal though gastroscopy has demonstrated severe lesions. Erosions are usually too shallow to show; nodules and verrucae cannot always be demonstrated. The folds, although often tortuous, may be easy to obliterate by pressure and may not appear stiff (Fig. 6).

Occasionally the demonstration of segmented folds (Henning), large, stiffened folds (Gutzeit) or nodules (Berg, Gutzeit, Weltz, Brunn and Pearl) may warrant a roentgenologic diagnosis of hypertrophic gastritis. Sometimes segmented folds show in mucosal relief films (Figs. 5, *C*, and 7) but they are not present in all cases of gastritis and occasionally are seen in normal stomachs. Cross-hatching of the folds by secretion, recognized by Kuhlmann, may be a cause. An overlying loop of small bowel may also give a similar pattern. The roentgenologic presence and gastroscopic absence of the segmentation may be a mechanical phenomenon. The folds not yet sufficiently infiltrated might be easily obliterated by the air introduction necessary for gastroscopy.

Infiltration of inflammatory products may cause stiffness which makes the folds difficult to obliterate with moderate pressure. The finding is of great help if they are large and traversed by peristaltic waves. However, in obese or muscular patients one never knows how much of the pressure exerted by the palpating hand is transmitted to the stomach.

Large folds are usually but not always of significance. They are sometimes present in normal stomachs. Schatzki has described congenital giant folds. If large folds are stiff and hard to obliterate with pressure, they are usually pathological. Differentia-

tion from submucosal infiltrating carcinoma is difficult, either gastroscopically or roentgenologically, especially if large verrucae are present. Frequently deep peristaltic waves pass through the stomach in gastritis (Fig. 8), a point helpful in differentiating gastritis from submucosal infiltrating carcinoma. It is significant if the fold pattern seen after a single swallow of barium fails to change when the stomach is filled and compressed.

Apparently the only roentgenologic sign of real value is the demonstration of small, rounded defects caused by nodular hypertrophy. Such defects are usually so small that they may only be seen on a mucosal relief film. Differentiation from small air bubbles, flecks of food or mucus cannot always be accomplished even with the aid of multiple views (Fig. 9, *A*). It is rare to see defects of this sort in films. We have seen only one case of the sort described by Brunn and Pearl, Berg and others, in which the nodules were so large that they could be seen roentgenoscopically (Fig. 9, *B*).

CHRONIC EROSIVE HYPERTROPHIC GASTRITIS

In this form of hypertrophic gastritis, described by Carswell in 1838, later by Faber, and believed by Schindler to be an acute stage of simple hypertrophic gastritis, the folds are hyperemic, edematous, thick and usually eroded.

Gastroscopically the erosions, some of which are surrounded by thick collars, may

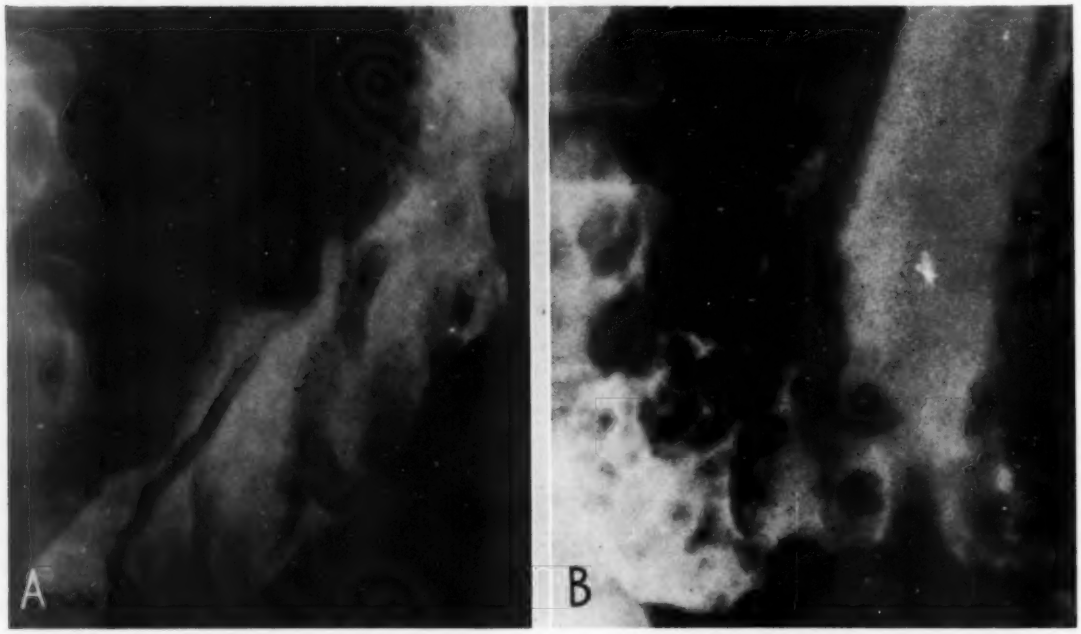

FIG. 9. *A*, severe hypertrophic gastritis with many small nodules was seen at gastroscopic examination. The small defect on the large folds in the body did not change position between various views, despite vigorous intervening palpation. This apparent fixation helps differentiate these small nodules from small air bubbles, mucus, flecks and food particles. A letter from the family physician two and one-half years later stated that the patient was alive and well.

B, severe hypertrophic nodular gastritis. Roentgenogram made with patient prone after application of pressure over the antrum of a barium-distended stomach. The normal gastric rugae are replaced by multiple polypoid defects. Note the normal-sized fold in the upper portion of the body, a region which at gastroscopy and on the resected specimen was involved with severe gastritic changes. At gastroscopy the appearance of the antrum was similar to that shown in Figure 5, *B*. The condition could not be differentiated from carcinoma by roentgenography or gastroscopy. At pathological examination severe gastritis and two small hemorrhagic polyps were found. There was no evidence of carcinoma in any of the multiple microscopic sections.

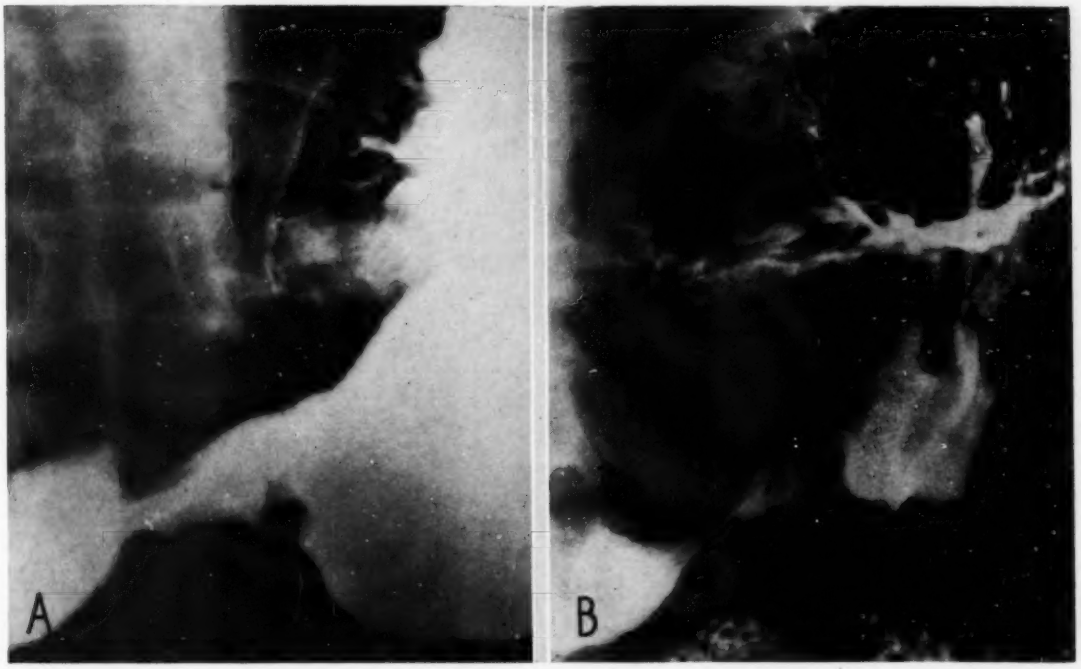

Fig. 10. *A*, same case as illustrated in Figure 5, *D*. The narrow antrum, sharply defined by the large fold seen on end along the greater curvature, persisted at roentgenoscopy. The large fold probably represents the infiltrated musculus sphincter antri. *B*, the mucosal roentgenogram does not indicate the presence of large folds.

be localized in the antrum (Fig. 5, *D*) or, more frequently, in the body of the stomach. They have been found also in the duodenum at autopsy.

Eastmond has described roentgenologic findings. The pyloric antrum is persistently narrowed but may occasionally change diameter within narrow limits. On compression the folds may be enlarged and stiffer than normal. As peristalsis reaches the antrum the involved segment contracts as one piece. In the one case of this sort that we have seen (Fig. 10) the folds were not enlarged. Differentiation from carcinoma is difficult. Berg believes that the presence of large, stiff, polypoid folds in the duodenal bulb speaks for gastroduodenitis rather than carcinoma.

PEPTIC ULCER

Table 1 is a summary of 44 gastric ulcers, each of which was examined gastroscopically and roentgenologically with intervals of at most a few days between the two examinations. Of the 7 cases in which the crater was seen only by roentgenography, the crater was located along the lesser curvature and posterior wall of the antrum in 3, along the lesser curvature of the body in 2, and immediately beneath the esophageal orifice in 2 (Fig. 11). Those craters in the antrum and beneath the esophageal

Table I

SUMMARY OF 44 CASES OF GASTRIC ULCER, EACH EXAMINED GASTROSCOPICALLY AND ROENTGENOLOGICALLY WITHIN A FEW DAYS

	Crater seen equally well by roentgenography and gastroscopy	Crater seen by roentgenography but not by gastroscopy	Crater seen by gastroscopy but not by roentgenography
Number of cases	33	7	4

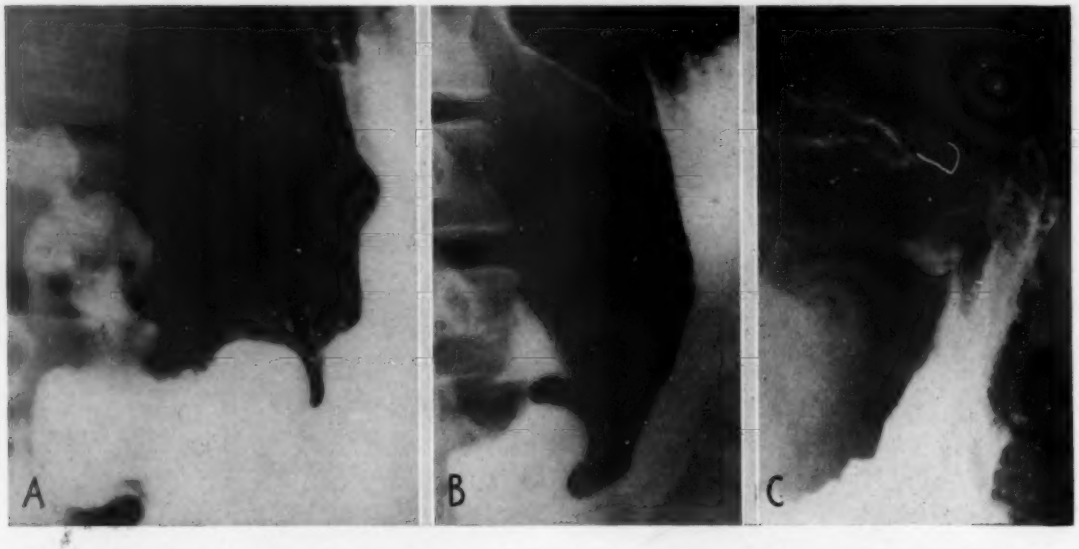

Fig. 11. Gastric ulcers not seen at gastroscopy. *A*, ulcer crater lies on the lesser curvature adjacent to the pylorus; *B*, ulcer crater in the midportion of the lesser curvature of the body; *C*, ulcer crater high on the lesser curvature.

orifice presumably lay in areas inaccessible to the gastroscope; those along the lesser curvature of the body were probably covered with folds. Of the 4 cases in which the crater was seen only by gastroscopy, 2 presented shallow lesions in the region of the incisura angularis, 2 were instances of large ulcer high on the posterior wall beneath the rib margin.

Eighteen of the gastric ulcers were followed both roentgenologically and gastroscopically during medical management (Table II). In 12 cases the crater disappeared roentgenologically at the same time it epithelized gastroscopically. In one case, best seen roentgenologically, a large crater, which was seen at the first gastroscopy, could not be found at three subsequent examinations, although it was easily seen roentgenologically, lying along the lesser curvature above the incisura angularis. In 5 of the cases the craters became shallow and invisible to the roentgenologist.

Tables I and II indicate that gastroscopy and roentgenology are equally dependable for the demonstration of gastric ulcer. If an ulcer can be seen gastroscopically, that is the method of choice for following the healing.

GASTRITIS AND ULCER

Cruveilhier first suggested that inflammation preceded the development of peptic ulcer. Konjetzny and his coworkers, reviving this old idea, have found micro-

Table II

SUMMARY OF 18 CASES OF GASTRIC ULCER IN WHICH THE HEALING WAS FOLLOWED BY BOTH ROENTGENOLOGY AND GASTROSCOPY

	Number of cases
Cases followed equally well by both methods	12
Cases followed best by roentgenology	1
Cases followed best by gastroscopy	5

scopic evidence of gastritis in 100 per cent of gastric ulcers. This is not in agreement with the gastroscopic findings as 9, or 19.5 per cent, of our 46 cases had no evidence of gastritis either at the first examination or at any time during the treatment. In 5 cases gastritis developed after treatment was instituted (Table III). In no case did the gastroscopist see typical erosive gastritis surrounding an ulcer crater.

Narrowing of the pyloric antrum that

TABLE III

SUMMARY OF THE MUCOSAL FINDINGS, AS SEEN THROUGH THE GASTROSCOPE, WHICH WERE ASSOCIATED WITH GASTRIC ULCER

Gastroscopic diagnosis		Only superficial gastritis	Only atrophic gastritis	Both superficial and atrophic gastritis	Hypertrophic gastritis	Totals
Inflammation:	about the ulcer	4	1	0	13*	18
	in other parts of the stomach but not about the ulcer	4	1	0	2	7
	involving the entire stomach	1	0	0	6	7
	not present at the initial examination but appearing during treatment	2	1	1	1	5
Totals		11	3	1	22	37
No inflammation present						9†

* One case gastroscoped after the ulcer disappeared at roentgen examination—hypertrophic gastritis in the region of the ulcer.
† One case gastroscoped after the ulcer disappeared at roentgen examination—no gastritis seen.

Hemorrhages and pigment spots lying in normal mucosa	seen at the initial examination	11
	appearing during or after treatment	12
Total		23

sometimes accompanies gastric ulcer has long been a subject of interest. Faber and Konjetzny believe that erosive gastritis of the antrum is frequently associated with gastric ulcer. Serck-Hanssen observed in 3 cases of surgically proved antral gastritis blank patches in the roentgen shadow of the pyloric canal. In one of these cases an ulcer was present on the lesser curvature of the stomach. Recently Golden suggested that the antral narrowing sometimes associated with gastric ulcer and described by

TABLE IV

TWENTY CASES OF ANTRAL GASTRITIS AND ANTRAL NARROWING ARE COMPARED. ALL OF THE CASES HAD AN ASSOCIATED GASTRIC ULCER

		Gastroscopic diagnosis	Number of cases
Cases having persistent roentgenologic evidence of antral narrowing	With antral gastritis	Hypertrophic Atrophic	5 1
	Without antral gastritis		3
Cases having no roentgenologic evidence of antral pathology but having gastroscopic evidence of chronic antral gastritis		Hypertrophic Superficial	9 2

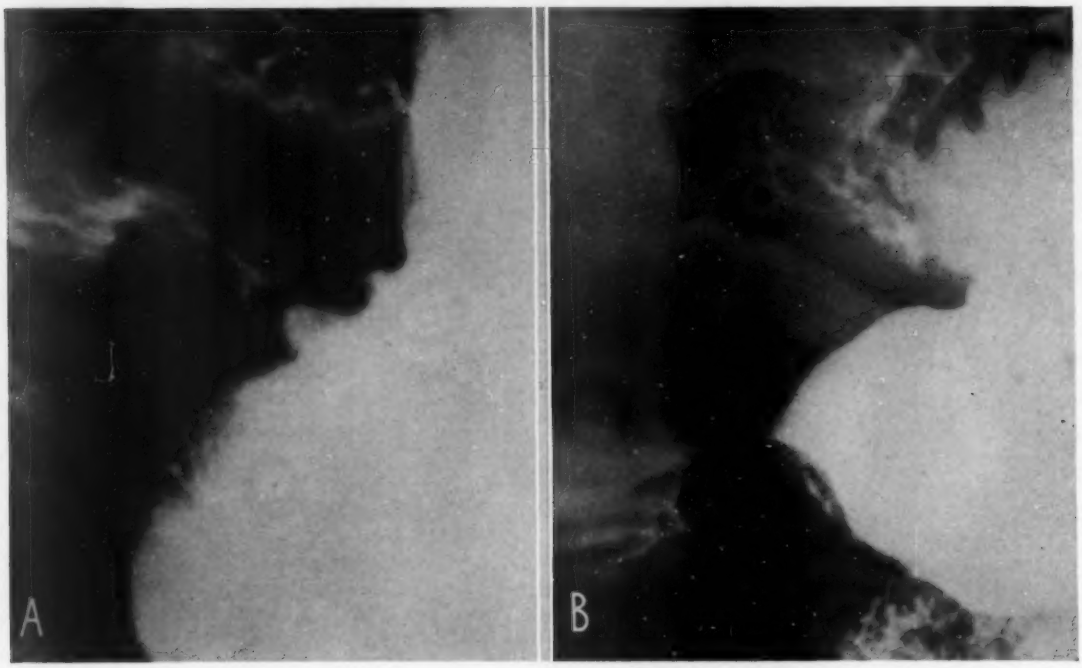

Fig. 12. Two cases of ulcer along the lesser curvature of the body with associated antral narrowing. *A*, a normal antrum was observed at gastroscopy. *B*, a hypertrophic antral gastritis without superficial ulcerations was seen at gastroscopy. The gastric ulcer is faintly seen buried in the crook of the lesser curvature.

Carman as reflex spasm might be the result of gastritis.

Among the 20 cases in Table IV, 9 showed narrowing of the antrum—6 with, 3 without associated gastritis. In 5 of these though the gastritis was of the hypertrophic type it was not erosive. In 11 the antrum was roentgenologically normal though the gastroscopist demonstrated the presence of gastritis (Fig. 12).

In an attempt to determine whether there is an association between gastritis and duodenal ulcer, 306 unoperated cases which had no gastroscopic or roentgenologic evidence of gastric ulcer or neoplasm were summarized in Tables V and VI.

The clinically active cases of duodenal ulcer were divided into three groups: (1) those having bulb deformity without demonstrable crater, (2) those having evidences of duodenitis without crater, and (3) those having definite demonstrable crater.

The presence of crater was established by roentgenoscopic examination and compression films. Crater was demonstrated in 39, or 66 per cent, of the 59 cases which were clinically active. This percentage, which is much higher than that obtained by some American roentgenologists, agrees with that obtained by other investigators who use compression methods and with that obtained previously by us in a series of 380 cases of duodenal ulcer. In some cases a diagnosis of crater doubtful at the first examination became definite as the examinations were continued during the course of medical management.

In 75 cases having duodenal ulcer, no evidence of gastritis was found in 20 of 59 clinically active cases, 3 of 11 clinically inactive cases and 2 of 5 cases having pyloric obstruction (Table V). In 92 of the 231 cases which had no roentgenologic or clinical evidence of duodenal ulcer, the gastric mucosa was normal (Table VI).

The fact that we have seen so many cases of chronic gastritis indicates that it is a common condition. On the other hand, percentage figures drawn from these tables

TABLE V

SUMMARY OF THE MUCOSAL FINDINGS, AS SEEN THROUGH THE GASTROSCOPE, WHICH WERE ASSOCIATED WITH DUODENAL ULCER

Gastroscopic diagnosis →		Hypertrophic gastritis		Superficial gastritis		Atrophic gastritis	Superficial + atrophic gastritis	Hemorrhages and pigment spots in normal mucosa	Normal	Totals
	Roentgen findings ↓	Mild	Severe	Mild	Severe					
Clinically active	Crater	10	5	5	2	1	0	10	6	39
	No crater	2	4	3	1	0	0	0	4	14
	Duodenitis	2	1	3	0	0	0	0	0	6
Clinically inactive	Crater	0	0	0	0	0	0	0	0	No cases
	No crater	2	0	2	1	2	0	1	3	11
Duodenal ulcer with obstruction		1	0	2					2	5
Totals		17	10	15	4	3	0	11	15	75

mean little because not all of the cases of peptic ulcer seen by us were gastroscoped and no patients were examined unless they presented a gastrointestinal complaint.

In 3 cases of gastric ulcer and 1 of duodenal ulcer the gastric mucosa was atrophic.

DISCUSSION

There are discrepancies between the gastroscopic and the microscopic diagnosis of gastritis. Several questions are raised. Have pathologists learned to differentiate between normal and abnormal gastric mucosa? Do the changes seen by the gastroscopist always indicate gastritis? Can gastritis exist without being visible through the gastroscope?

These questions cannot be answered definitely but the evidence suggests that inflammatory changes of the submucosa or muscularis propria can exist without giving gastroscopic findings. In one case, gastroscopic examination a few days before gastric resection for duodenal ulcer showed a normal mucosa. Pathological sections re-

TABLE VI

SUMMARY OF THE MUCOSAL FINDINGS, AS SEEN THROUGH THE GASTROSCOPE, IN STOMACHS WITHOUT EVIDENCE OF ULCER, NEOPLASM OR ASSOCIATED DUODENAL ULCER

Gastroscopic diagnosis	Hypertrophic gastritis	Superficial gastritis	Atrophic gastritis	Superficial + atrophic gastritis	Hemorrhages and pigment spots in normal mucosa	Normal	Totals
Cases having no evidence of gastric or duodenal ulcer	42	30	40	18	9	92	231

vealed no definite mucosal abnormalities but there was definite cellular infiltration in the muscularis propria. Henning has suggested that this sort of infiltration in the propria may explain some of those cases in which the roentgenologist sees large folds but the gastroscopist reports normal mucosa.

In treated cases the gastroscopist may note spectacular improvement in the mucosa but it is rare for the roentgenologist to detect any change whatever. Extremely stiff folds may become slightly more pliable but large folds have seldom been seen to decrease in size.

CONCLUSIONS

1. Chronic gastritis, diagnosed easily through the gastroscope, can rarely be diagnosed with certainty by present roentgenologic methods. This is particularly true of the superficial and atrophic forms.

2. Usually gastric ulcer can be diagnosed equally well by both methods but occasionally an ulcer may be seen by one method and not by the other. It follows that the methods should be used together whenever this is possible.

3. When an ulcer is located so that the gastroscopist can see it, gastroscopy is the method of choice for following the course of healing under management. In most cases, however, the course of healing can be followed almost as well by carefully conducted roentgenologic examinations.

4. Gastroscopic evidence of gastritis is not present in all cases of gastric or duodenal ulcer.

5. The antral narrowing sometimes accompanying gastric ulcer occasionally but not always presents gastroscopic evidence of gastritis.

6. Inflammatory changes in the deeper layers of the stomach wall may give roentgen findings of gastritis but no gastroscopic findings.

REFERENCES

1. ÅKERLUND, Å. Röntgenologische Studien über Bulbus duodeni mit besonderer Berücksichtigung der Diagnostik des Ulcus duodeni. *Acta radiol.*, Suppl. 1, 1921.
2. ÅKERLUND, Å. Present-day criteria of x-ray diagnosis of duodenal ulcer. *Am. J. Surg.*, 1931, *11*, 233–259.
3. ALBRECHT, H. U. Die Röntgendiagnostik des Verdauungskanals. Georg Thieme, Leipzig, 1931.
4. BEAUMONT, W. Experiments and Observations on the Gastric Juice, and the Physiology of Digestion. F. P. Allen, Plattsburgh, 1833.
5. BERG, H. H. Die direkten Röntgensymptome des Ulcus duodeni und ihre klinische Bedeutung. *Ergebn. d. med. Strahlenforschung*, 1926, Vol. 2.
6. BERG, H. H. Röntgenuntersuchungen am Innenrelief des Verdauungskanals. Georg Thieme, Leipzig, 1930.
7. BRUNN, H., and PEARL, F. Diffuse gastric polyposis, adenopapillomatosis gastrica. *Surg., Gynec. & Obst.*, 1926, *43*, 559–598.
8. CHAOUL, H. Reports of Third International Congress of Radiology, p. 335.
9. CARMAN, R. D. Spasms of the stomach and duodenum from a roentgenologic point of view. *J. Am. M. Ass.*, 1916, *66*, 1283–1288.
10. CARSWELL, R. Pathological Anatomy. Longman, London, 1838.
11. CRUVEILHIER. Quoted by Eusterman, G. B., and Balfour, D. C. The Stomach and Duodenum. W. B. Saunders Co., Philadelphia, 1935.
12. DUVAL, P., ROUX, J., BÉCLÈRE, H., and MOUTIER, F. Reports of the Third International Congress of Radiology, p. 283.
13. EASTMOND, C. Gastro-intestinal infection; its roentgen manifestations. *Brit. J. Radiol.*, 1926, *31*, 93–98.
14. v. ELISCHER, J. Ueber eine Methode zur Röntgenuntersuchung des Magens. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1911–1912, *18*, 332–340.
15. EWALD, C. A. Quoted by Faber, ref. 16.
16. FABER, K. Gastritis and its Consequences. Oxford Medical Publications, 1935.
17. FENWICK, S. Quoted by Faber, ref. 16.
18. FORSSELL, G. Studies on the mechanism of movement of the mucous membrane of the digestive tract. AM. J. ROENTGENOL. & RAD. THERAPY, 1923, *10*, 87–104.
19. FOX, W. Quoted by Faber, ref. 16.
20. GUTZEIT, K. Ueber die Magenschleimhaut bei chronischer Gastritis. *Deutsches Arch. f. klin. Med.*, 1926, *153*, 334–345.
21. GUTZEIT, K. Schleimhautdiagnostik des Magens. *Wien. med. Wchnschr.*, 1931, *81*, 251; 293; 320.
22. GOLDEN, R. Antral gastritis and spasm. *J. Am. M. Ass.*, 1937, *109*, 1497–1500.
23. HENKE, F., and LUBARSCH, O., Editors. Handbuch der speziellen pathologischen Anatomie und Histologie. J. Springer, Berlin, 1928, Vol. 4.

24. Henning, N. Die Entzündung des Magens. J. A. Barth, Leipzig, 1934.
25. Jones, H. *Med. Chir. Tr.*, 1854, *19*, 87–151.
26. Konjetzny, G. E. Die chronische Gastritis des Ulcusmagens. *Zentralbl. f. Chir.*, 1923, *50*, 1026–1028.
27. Konjetzny, G. E. Zur Gastritisfrage. *Wien. klin. Wchnschr.*, 1933, *46*, 451–458.
28. Kuhlmann, F. Was leistet die Röntgenuntersuchung für die Gastritisdiagnose? *Med. Klin.*, 1935, *31*, 1390–1393.
29. Pape, R. Zur Frage der Magenschleimhautatrophie im Röntgenbild bei perniziöser Anämie. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1934, *50*, 327–336.
30. Rendich, R. A. Roentgenographic study of the mucosa in normal and pathological states. Am. J. Roentgenol. & Rad. Therapy, 1923, *10*, 526–537.
31. Schindler, R., and Ortmayer, M. Classification of chronic gastritis with special reference to gastroscopic method. *Arch. Int. Med.*, 1936, *57*, 959–978.
32. Schindler, R. Gastroskopische Untersuchungen über die Heilung des Ulcus rotundum ventriculi. *München. med. Wchnschr.*, 1926, *73*, 1846.
33. Schindler, R. Gastroscopy: The Endoscopic Study of Gastric Pathology. University of Chicago Press, 1937.
34. Schindler, R., and Templeton, F. A comparison of gastroscopic and roentgen findings. *Radiology*, 1937, *29*, 472–479.
35. Schindler, R., and Sielmann, H. Ueber gastroskopische Kontrollen röntgenologischer Reliefbilder der Magenschleimhaut. *München. med. Wchnschr.*, 1931, *78*, 1989–1991.
36. Serck-Hanssen, F. Roentgenograms of pyloric hypertrophy and prepyloric spasms in chronic gastritis and gastric ulcer. *Norsk. Mag. f. Laegevidensk.*, 1932, *93*, 609. Abs. *J. Am. M. Ass.*, 1932, *99*, 874.
37. Templeton, F. E., and Heinz, T. E. Duodenal ulcer; roentgenologic demonstration of the crater. *J. Am. M. Ass.*, 1937, *108*, 501.
38. Weltz, G. A. Hyperplastische Gastritis. *Röntgenpraxis*, 1931, *3*, 577–580.

LEIOMYOSARCOMATOSIS OF THE SMALL INTESTINE

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LEIOMYOSARCOMA of the small intestine is a relatively rare disease, and for this reason, as well as the differential diagnosis it involves, the following case is reported and a review of the literature to date is presented.

The patient, a white male, carpenter, aged sixty-seven, was admitted to the Medical Service of Lincoln Hospital for dyspnea, slight edema of the legs, flatulence, epigastric distress, and tarry stools of two months' duration. The patient also complained of precordial pain, not related to effort, but relieved by passage of flatus. Two weeks prior to admission, the patient vomited several times, but no blood was noted in the vomitus. He complained constantly of flatulence and abdominal cramps. The patient had a normal bowel movement every day, but for the past six weeks he noted that his stools were black in color.

Physical examination revealed an elderly white male appearing chronically ill, with evidence of marked anemia. The eyes were negative; there was marked pallor of the mucous membranes; the tongue was slightly atrophic at the edges. The chest was emphysematous in type; the lungs were clear and resonant with distant breath and voice sounds. The heart was not enlarged, sounds of fair quality, no thrills or murmurs, regular sinus rhythm. The abdomen was distended, but no rigidity, tenderness or masses were felt. Extremities were markedly pale with slight edema of the ankles. Rectal examination was negative.

Examination of the urine was completely negative. Red blood cells 2,650,000 with hemoglobin 40 per cent (Sahli), white blood cells 14,950 with 76 per cent polymorphonuclears. Microscopic examination of the blood smear revealed microcytosis, hypochromia and anisocytosis.

Bleeding time was 1.75 min.; clotting time was 3 min. Platelets were 400,000.

Stool examination was positive for blood both by benzidine and guaiac tests, and continued to be so on subsequent examination.

The diagnosis on admission was malignant disease of the gastrointestinal tract, site to be determined, and anemia secondary to blood loss. Electrocardiogram showed evidence of moderate myocardial fibrosis.

Roentgenographic examination of the colon, performed soon after admission, failed to show evidence of obstruction or other lesion in any part of the colon. Roentgen examination of the stomach and small intestine was reported at first as normal. However, these films were reviewed later and several large round filling defects were described projecting into the lumen of the jejunum. These were proved at necropsy to be the site of the pathology.

Proctoscopic and sigmoidoscopic examinations were negative. Gastric analysis revealed no free HCl, and only a slight rise after injection of histamine.

The patient ran a steadily downhill course in the hospital. The stools were repeatedly positive for blood and the red blood cell count dropped until it reached 1,000,000 with 30 per cent Hb, two and one-half months after admission. Several transfusions were given without avail. Patient became irrational, more anemic, developed bronchopneumonia and died three months after admission.

At necropsy the body was that of an emaciated white male with very marked pallor of the tissues. The significant pathology was limited to the abdomen. On opening the abdomen, several large masses were noted lying in the mesentery, the largest the size of an orange. The stomach contained an ulcerated area lying in dark red tumor tissue which infiltrated the stomach wall. The duodenum was normal. At the origin of the jejunum and extending down into the ileum were several ulcerated areas similar to that seen in the stomach. Several of the larger ulcerations lay in dark red hemorrhagic and necrotic tumor tissue which had invaded all the coats of the jejunum. One of the tumors had become pedunculated, projected into the lumen of the jejunum, and by traction had produced a jejunal intussusception. The ulcerated areas and tumor tissue became more scarce as the ileum was approached, and only one area of tumor tissue was found in the ileum. The mesenteric and peripancreatic nodes were also enlarged and presented the same type of

tumor tissue as the jejunum. No other metastatic foci were found.

Microscopic sections from the stomach ulcer showed malignant smooth muscle cells invading and replacing the mucosa. Section from one of the tumors in the jejunum revealed smooth muscle cells with very large hyperchromatic nuclei, many mitoses, and bizarre forms. Section from a second tumor revealed undifferentiated muscle cells, enmeshed in a fine reticular network.

The final diagnosis was "multiple leiomyosarcomata of the stomach, jejunum, and ileum with metastases to the mesenteric and peripancreatic lymph nodes."

INCIDENCE

The first authentic case was published by Foerster in 1858 and was entitled "A fibroid of the muscularis of the ileum."

Andersen and Doob in 1933 reviewed the literature on the subject of leiomyosarcoma of the small intestine and listed 18 cases which had been reported since 1875. In their paper, they reported a case of leiomyosarcoma of the duodenum, making the third such reported. Klopp and Crawford in 1935 reported 2 more cases, 1 with recurrence thirteen years after resection. There have been many cases of benign tumors of the small intestine, but definitely proved malignant smooth muscle tumors of the small intestine are relatively rare, 22 being reported to date including the present case. According to Speese, the ratio of leiomyosarcoma of the small intestine to other tumors of the small intestine is 1:96. This case is still more unusual in that it is the first case reported presenting multiple leiomyosarcomata.

Fig. 1. Roentgenogram after barium meal showing several large, round, filling defects in the terminal loops of jejunum.

Fig. 2. Detail of the jejunal tumors seen in Figure 1.

PATHOLOGY

There is no definite etiological factor known as yet which produces smooth muscle tumors.

Steiner found these tumors near areas of diffuse hypertrophy of the musculature of the stomach and intestines, and thought they might be related to irritation. Winkle believed these tumors are due to inflammation caused by syphilis or other inflammatory processes. However, none of these theories are tenable today.

The immediate origin appears to be located in any of the muscle coats of the intestinal wall, such as the circular or longitudinal muscle coats, or the muscularis mucosae. Some believe that they arise from the muscle coats of the blood vessels in the intestines.

In their growth, these tumors form either an external or internal type. The external variety arises from the longitudinal muscle coat, the internal variety from the circular layer or muscularis mucosae. When arising from the muscularis mucosae, the constant traction of the intestinal peristalsis usually produces a typically pedunculated tumor, which is often the cause of intussusception.

The malignant changes of the benign myomata of the intestine have always been a controversial subject. Zeit believes that malignant degeneration may take place, but that benign metastases, chiefly to the liver, may also occur. Here they are usually destroyed, but some may survive and set up secondary benign foci. Most patholo-

FIG. 3. Gross specimens showing six intestinal tumors with necrosis and hemorrhage.

gists believe, however, that true sarcomatous degeneration of these tumors does occur.

The criteria for malignancy are very difficult to establish in many cases. Only 4 of the 19 cases reported by Andersen and Doob metastasized, the tumors tending to grow in bulk and not to metastasize. Also many cases are reported as myosarcoma where special stains for myofibrillae were not done, without which it is practically impossible at times to differentiate myosarcoma from fibrosarcoma.

Most of the tumors are characteristically hard, coarse, nodular, and rather avascular structures, prone to degeneration in the center and to ulceration through the mucosal surface of the bowel (occurred in 7 of 19 cases).

Microscopically, these tumors show interwoven bundles of spindle cells, arranged in columns, or palisades, pleomorphic nuclei, which are rod shaped and hyperchromatic. Mitoses are relatively rare. The stroma is scanty and avascular. The presence of a very vascular stroma favors the diagnosis of fibrosarcoma. With Mallory's stain, delicate protoplasmic myofibrillae can be seen.

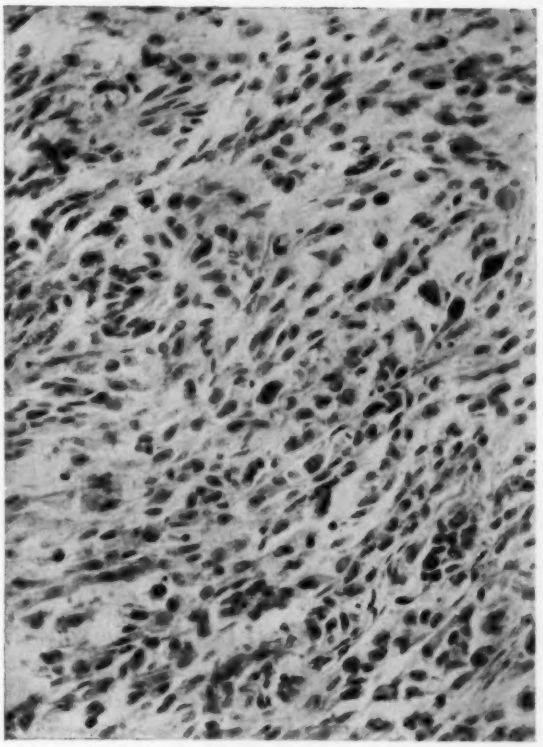

Fig. 4. Photomicrograph of a section through one of the leiomyosarcomata showing neoplastic smooth muscle cells and fine myofibrillae.

SYMPTOMATOLOGY

Clinically, these tumors can be divided into two different types depending on the position of the tumor.

1. *External Myoma.* In this type which really arises from the longitudinal muscle coat, the growth is outward and the leaves of the mesentery of the visceral peritoneum are pushed away. This variety may reach extremely large proportions. In one case reported by Wolfer, the tumor weighed 15½ pounds. Adjacent organs are usually distorted and compressed, and pressure atrophy of the liver and pancreas may result.

The outstanding sign is the presence of a tumor which is freely movable, frequently nodular, and not especially tender. The rate of growth is comparatively slow (one case reported with recurrence thirteen years after resection of primary tumor). As a rule, when the growth originates in the wall of the small intestine, it produces greater disturbances in intestinal function than when it originates from the colon. This is due to the formation of traction diverticula and adhesions which occasionally results in intestinal obstruction.

Strangulation or incarceration of the tumor may occur as in a case reported where the tumor was incarcerated in a hernial sac. Due to secondary changes in the mucosa, late development of diarrhea, blood and mucus may occur.

2. *Internal Myoma.* These usually arise from the muscularis mucosae, and rarely attain a great size due to their encroachment on the lumen of the gut and production of early intestinal obstruction. These tumors usually ulcerate and free bleeding usually occurs which may be the first and only symptom, as in the case reported by us.

These tumors are usually pedunculated and, in a few cases reported, the tumor broke off from its pedicle and was passed by rectum with spontaneous recovery. The bleeding may be of any degree from occult blood to exsanguinating hemorrhage.

When partial obstruction develops, cramps, vomiting, obstipation, and varying degrees of distention usually occur. These symptoms may disappear, and with their disappearance, the patient passes large quantities of foul, bloody, diarrheal stools. Many of these patients later develop the classical picture of intussusception which is characterized by a frequent sudden and spontaneous relief and then recurrence. When intussusception occurs, it may be possible to feel the tumor in the abdomen. Intussusception is more likely to occur with benign than malignant tumors.

The above clinical pictures may occur both in benign and malignant myomata of the small intestine.

Occasionally these tumors may perforate resulting in an acute abdominal emergency greatly simulating a ruptured viscus. Cattell and Woodbridge describe such a case.

ROENTGENOLOGICAL FINDINGS

The roentgenological diagnosis of the external type is suspected when one notes displacement of several adjoining viscera by a large mass, in the presence of a suitable history. Distortion of the gastrointestinal, genitourinary and biliary tracts as shown by roentgenographic studies may be needed to establish the diagnosis. As a rule, the results are unsatisfactory.

The roentgenological diagnosis of the internal type is suspected when there is evidence of intestinal stasis as in delay in passage of barium meal, retention of barium flecks in the small intestine, and a small round, filling defect in the loops of small intestine.

As all but 2 of the 19 cases previously reviewed showed the growth external to the lumen of the intestine, roentgenological study of the gastrointestinal tract does not often seem to be of aid, but should be carried out.

SUMMARY

1. A case of multiple leiomyosarcoma of the small intestine is presented. This appears to be the first case of multiple leiomyosarcoma of the intestines to be reported.

2. Leiomyosarcoma of the small intestine is a relatively rare tumor, occurring in one out of every 96 cases of small intestinal tumors.

3. They may be divided roughly into an internal and external type. Although the diagnosis may be made clinically, there is no definite clinical syndrome, and the diagnosis is usually made by the pathologist.

4. The roentgenological study of the gastrointestinal tract is unsatisfactory as a rule, and the diagnosis is rarely made by this means.

REFERENCES

1. ANDERSEN, D. H., and DOOB, E. F. Leiomyosarcoma of duodenum. *Arch. Path.*, 1933, *16*, 795–802.
2. BONNEAU, R. Leiomyome malin de l'intestin grêle. *Bull. et mém. Soc. de chir. de Paris*, 1928, *20*, 52.
3. BRINK, J. R., and LAING, G. H. Leiomyosarcoma of jejunum. *Arch. Path.*, 1933, *15*, 316–317.
4. CATTELL, R. B., and WOODBRIDGE, P. D. Leiomyosarcoma of the jejunum. *Surg. Clin. North America*, 1931, *11*, 363–370.
5. DIXON, C. F., and STEWARD, J. A. Leiomyoma of the jejunum. *Surg., Gynec. & Obst.*, 1933, *56*, 801–804.
6. EWING, J. Neoplastic Diseases. W. B. Saunders Co., Philadelphia, 1935, p. 233.
7. KLOPP, E. J., and CRAWFORD, B. L. Leiomyoma of the small intestine. *Ann. Surg.*, 1935, *101*, 726–733.
8. MCFARLAND, J. Malignant myoma. *Am. J. Cancer*, 1935, *25*, 530–543.
9. STEINER, R. Ueber Myome des Magen-Darmkanals. *Beitr. z. klin. Chir.*, 1898, *22*, 1-112; 407–440.
10. STOUT, A. P. Human Cancer. Lea & Febiger, Philadelphia, 1932.
11. WOLFER, J. A. Leiomyomata of intestine. *Surg., Gynec. & Obst.*, 1928, *47*, 643–651.

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GASTROCOLIC FISTULA FROM CARCINOMA OF THE PANCREAS*

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GASTROCOLIC fistula was recognized as early as 1755, but until the advent of roentgen diagnosis recognition of the condition, except on the autopsy table, was infrequent. Most cases are due to carcinoma of stomach or colon. In 1903 Czerny[2] reported the first case following gastroenterostomy. Other cases have been reported due to ulcer, tuberculosis, abscess of the peritoneum and tuberculous peritonitis. We have not, however, found one in which new-growth of the pancreas was given as a factor. Nearly all the reported cases are in the male; here again our case is unusual.

Symptomatology is frequently vague. The characteristic symptoms of the disease, fecal vomiting and lienteric diarrhea, are usually grafted upon those of the preexisting condition and their significance may be missed. Starkey-Smith[4] reported a case which ran its course with a diagnosis of enteric fever; Fairley[3] cited one, originating while the patient was living in the tropics, diagnosed as sprue.

Diagnosis by the roentgen ray offers the best possibilities but cannot always be depended upon. Verbrugge,[5] in a very complete article in which he collected 202 cases from the literature and reported 21 from the Mayo Clinic, noted that in 8 of these the method failed. The reason for this is the redundancy of the gastric mucosa, which may cover the fistula from above downward, and acting like a ball-valve, prevent the opaque material, given orally, from passing through, as noted by Betts.[1] In such instance, the barium enema often solves the problem, as in our case; but the reverse may be true, and the enema fail where oral administration succeeds. Both methods should be used in suspected cases.

CASE REPORT

A white female, aged forty-nine, housewife, was admitted to the Worcester City Hospital, December 22, 1937, complaining of weakness, loss of appetite and loss of weight. She had noticed the weakness for the past six weeks. Her loss of appetite has been definite for a period of three months. She estimated that she lost 20 lb. in weight in the same period. She has vomited occasionally during the past six weeks without relationship to meals. She has had night sweats for the past week coming on about 4 o'clock each morning. She had a traumatic amputation of the right leg at the level of the middle tibia at seven years of age. She had four subsequent operations to remove pieces of bone. Seven years ago patient had a premature delivery of a dead fetus. She has had no menstruation since. Physical examination reveals a well-developed, white female with a slight tendency toward obesity but with evident loss of weight and apparently anemic. Her right lower leg is missing as described above. Her abdomen reveals a mass in the left upper quadrant which is palpable four fingers' breadth below the costal margin. This was thought at first to be spleen. The liver edge is not palpable. No other masses are palpable. The red blood count on admission was 3,500,000 with a hemoglobin of 46 per cent. White blood count was 20,500. Smear showed no evidence of leukemia. Because of a temperature fluctuating between 99 and 102° F., a blood culture was taken which showed no growth. Agglutinations for typhoid, paratyphoid A and B, and *Bacillus abortus* were negative. One stool examination was positive for occult blood.

Roentgen Examination. On December 23, 1937, a barium enema was given. The opaque material entered readily to the region of the splenic flexure, beyond which it filled a very much deformed stomach, showing an extensive defect on the greater curvature (Fig. 1). Emptying took place through the pylorus and the duodenal bulb was well filled. The colon beyond the splenic flexure also filled well as far as a rather large cecum. There were two

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Fig. 1. Roentgenogram taken after barium enema. Note filling of stomach, double fistulous channels, and emptying through pylorus.

fistulous openings a short distance apart, with a total diameter of about 3 cm. at the junction with the large gut. The impression was of massive gastric carcinoma with spontaneous gastrocolic fistula. A survey of the chest was negative.

On December 27, 1937, a meal given from above under the screen confirmed the impression of the large gastric filling defect, but none of the material passed through the gastrocolic fistula during the period of observation (Fig. 2). The pylorus and bulb appeared normal as at the previous examination.

The patient was given transfusions and parenteral fluids because of almost constant vomiting. In spite of the roentgen diagnosis of gastrocolic fistula from a gastric carcinoma, the patient's condition did not warrant operation at any time. She died twenty-five days after admission.

Autopsy Findings. Following are the positive findings at autopsy which was limited to the abdomen.

The body is that of a well-developed and fairly well-nourished white female, forty-nine years of age, 61 inches (152.5 cm.) tall and weighing 99 lb. (45 kg.). Rigor mortis is partial and lividity is marked. There are multiple puncture wounds in both antecubital fossae and petechiae over both patellae. The pupils are round and equal, and measure 7 mm. in diameter, each. The teeth are false. The right leg is amputated 23 cm. above the ground.

Peritoneal cavity: There is a small amount of fibrin scattered over the small intestine and parietal peritoneum and about 75 cc. of greenish-gray, rather thick, purulent material is scattered throughout. Omentum is adherent to the abdominal wall in a few places in the upper left quadrant and to a mass in that area into which it is incorporated.

Spleen: Weight about 120 gm. It measures 12×7×4 cm. It is of normal color except for a slightly raised, firm, whitish area on the anterior surface of the lower pole about 2 cm. in diameter. Cross-section is normal except for irregular, white area described above.

Gastrointestinal tract: Thoracic esophagus is negative. There is a mass, 15×10×7 cm., in the left upper quadrant. It is firm, arranged in irregular lobes interspersed with fatty tissue of the omentum in which it lies, and strands of the

Fig. 2. Roentgenogram taken after barium meal. Note non-filling of large intestine.

whitish tissue invade the fat. The mass involves the greater part of the greater curvature and posterior wall of the stomach; it is contiguous and apparently continuous with the pancreas, and the transverse colon is fixed to it below, near the splenic flexure. On the lower free border of the tumor is a single, clear cyst, 2.5×2 cm. The stomach, tumor mass, transverse colon, liver, spleen and pancreas are removed *in toto*. The stomach is opened and found to contain dark, foul smelling, fecal material. The mucous membrane is darkly discolored throughout, especially the posterior wall and the greater curvature where it is almost black. It is also friable and appears necrotic. There is a tremendous ulcer in the greater curvature about the midportion of the stomach, 10×10 cm. Its edges are raised and irregular. The perforation through this ulcer enters a cavity inside the tumor mass and then communicates with the transverse colon through a contiguous perforation there. A loose flap of tissue appears to close this perforation through the base of the ulcer. The perforation in the colon is found to be double, the two being separated by a small band of tissue. The stomata measure 1.5 and 2.5 cm. in diameter. The lumen of the colon does not appear to be narrowed, except possibly by pressure of the mass and it is not involved in the neoplasm except at the point of perforation. The remainder of the gastrointestinal tract is negative except for the occasional accumulation of fibrin found on the serous surfaces of the intestines.

Pancreas: It cannot be dissected free from the tumor mass and is apparently involved in it. Pancreatic tissue resembles the tumor tissue.

Kidneys: Left kidney weighs 130 gm. The capsule strips fairly easily leaving a slightly granular surface. Cut surface is negative except for slight irregularity of markings. Right kidney weighs 140 gm. Capsule strips easily and leaves a smooth surface with many irregularly outlined, white patches. Cut surface shows in one-half of kidney a whiteness of the cortical region without involvement of the medulla. The remainder of the kidney is pale, yellowish-pink and the markings are very indistinct and distorted, with little normal appearing kidney tissue. The ureters are negative.

Anatomical Diagnosis. Adenocarcinoma of pancreas with extension into stomach and transverse colon; gastrocolic fistula; cortical necrosis of right kidney; hydronephrosis, slight; arteriosclerosis of the aorta, moderate.

SUMMARY

A case of gastrocolic fistula is reported, unusual in that it originated from cancer of the pancreas. Attention is called to the failure to demonstrate the fistula by the oral meal, due to redundancy of the gastric mucosa—a possible cause of error in diagnosis unless both methods of examination are used in all suspicious cases. This condition also undoubtedly aided in maintaining the nutrition of the patient in the presence of so formidable a lesion.

REFERENCES

1. Betts, A. Gastrocolic fistula. *Northwest Med.*, 1930, *29*, 509–511.
2. Czerny, V. Zur Behandlung der Fissur und des Vorfalls des Mastdarms. *Beitr. z. klin. Chir.*, 1903, *37*, 765–769.
3. Fairley, N. H., and Kilner, T. P. Gastro-jejuno-colic fistula, with megalocytic anaemia simulating sprue. *Lancet*, 1931, *2*, 1335–1341.
4. Starkey-Smith, T. G. Case of carcinomatous gastrocolic fistula simulating enteric fever. *Brit. M. J.*, 1932, *1*, 982–983.
5. Verbrugge, J. Gastrojejunocolic fistulas. *Arch. Surg.*, 1925, *11*, 790–808. Abridged paper in *Collected Papers Mayo Clinic*, 1924, *16*, 104.

AN INTERESTING ANOMALY*

By CHARLES WADSWORTH SCHWARTZ, M.D.
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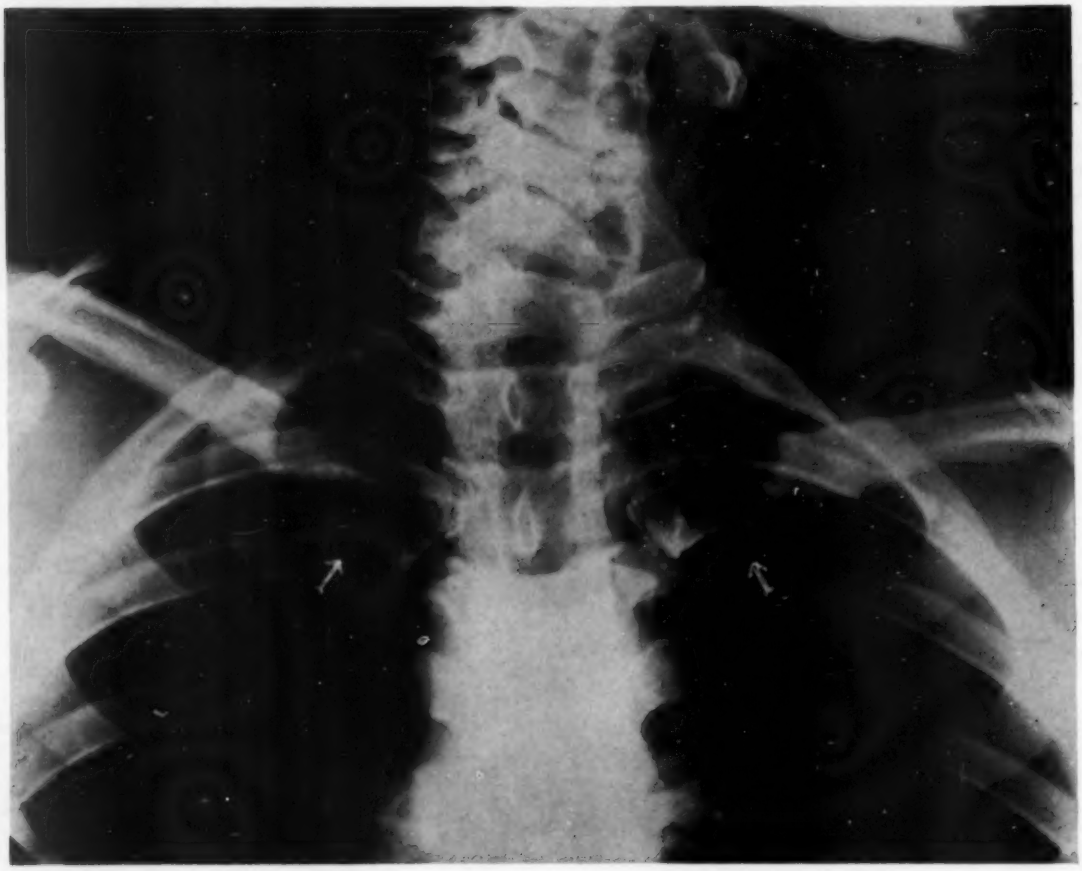
THE accompanying illustration shows an anomaly of the clavicles which is not frequently encountered. On close inspection one can see irregular but roughly semicircular indentations on the under surfaces of the sternal heads of both clavicles. There is no suggestion of the bone being pathological either in its appearance or from the case history. This area corresponds to the portion of the bone allotted to the attachment of the rhomboid ligament which passes from the clavicle to the cartilage of the first rib. These indentations are usually asymmetrical and may be small or large. At times the ligament may be found to be attached to a raised portion of bone. In either case one should not be led to suspect the presence of pathology. (I am indebted to Dr. Ross Golden for suggestions as to the origin of this anomaly.)



REFERENCE

PENDERGRASS, E. P., and HODES, P. J. The rhomboid fossa of the clavicle. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 152–155.

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COMPLICATIONS PRODUCED BY MALIGNANT TUMORS OF THE NASOPHARYNX*

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EXCELLENT descriptions of the clinical syndromes produced by malignant neoplasms of the nasopharynx have appeared in the literature at intervals for thirty-seven years and yet the medical profession as a whole is still quite unfamiliar with the many manifestations of the disease. Escat[2] published a creditable description of the signs and symptoms in 1901 and Oppikofer[11] reviewed 250 cases published prior to 1913 and added 21 of his own, but Woltman[12] observed that only one case in a series of 25 which he examined at the Mayo Clinic in 1922 had been correctly diagnosed. Some of the erroneous diagnoses were: tonsillitis, diseased teeth, sinus disease, trifacial neuralgia, nasal polyps, deflected septum, otitis media, pharyngeal abscess, Hodgkin's disease, mumps, pituitary tumor, dementia paralytica and syphilis. New,[9,10] Hansel,[5] Furstenberg,[4] and others, have since published comprehensive reviews of the subject and yet New[10] in studying 194 cases seen at the Mayo Clinic prior to 1931 noted that 185 operations had been performed for conditions other than cancer of the pharynx because of incorrect diagnoses, and Needles,[8] in reporting 35 cases in one of New York's larger hospitals treated prior to 1937, observed that 12 patients were subjected to unnecessary operations before the correct diagnoses were made.

The primary tumor usually is located high up on the lateral wall of the pharynx in or near the fossa of Rosenmüller, but neoplasms arising in the sphenoid sinuses and even in the pituitary gland have been reported, and in one of our own patients the point of origin apparently was situated on the lateral wall of the posterior nasal passage. Furstenberg reports a carcinoma situated entirely within the eustachian tube. The progress of the disease paralleled that seen with other pharyngeal tumors and yet the primary growth could neither be visualized nor biopsied. In many instances severe symptoms result from secondary extensions while the primary tumor remains so small that its detection taxes the skill of a trained laryngologist.

Pathologists disagree as to the exact terminology which should be used in describing malignant tumors in this region. Lymphosarcomas, epidermoid carcinomas, transitional cell carcinomas, lymphoepitheliomas and adenocarcinomas have been described by competent men, and New expresses the opinion that all of those arising from the epithelial structures should be called squamous cell epithelioma, Grade 4. Fortunately, all of the malignant neoplasms in the pharynx are very radiosensitive and their histopathology is not of any great clinical importance.

LOCAL GROWTH

As the primary tumor grows it may produce epistaxis, nasal obstruction, nasal discharge, postnasal pain, chronic sore throat, dysphagia and the sensation of a lump in the throat but curiously enough these symptoms often appear late in the disease, if at all. In Needles' series only 6 of 35 cases had any such manifestations early, and New stated that only about half of his large group complained of symptoms produced by the primary growth.

With extension into the adjoining soft tissues the eustachian tube soon becomes blocked, and deafness, tinnitus, a feeling of stuffiness in the ears, retraction of the drum and otitis media usually result. The anterior pillar of the affected side is pushed forward and eventually the soft palate may be invaded. Later the pterygoid and mas-

* Read at the Twenty-third Annual Meeting, American Radium Society, San Francisco, Calif., June 13–14, 1938.

seter muscles are attacked and the victim can then open the mouth very little if at all.

INTRACRANIAL EXTENSION

In about one-third of the patients afflicted with pharyngeal carcinoma the sphenoid bone is invaded. The thin structure forming the floor of the middle fossa on either side of the sella turcica is either completely destroyed or becomes moth-eaten in appearance and malignant tissue grows into and around the sella, often displacing but practically never invading the pituitary gland. The posterior horn of the sella and sometimes the floor may be eroded and the petrous tip of the temporal bone is at times destroyed. The tumor grows in both directions, entering the orbit through the sphenoid fissure anteriorly and extending backwards between the dura and the floor of the skull to produce pressure on one cranial nerve after another. Only a few isolated cases have been reported in which the dura was perforated and the brain invaded.

Lateral roentgenograms of the skull reveal the damage about the sella turcica and carefully made vertical views often show the destruction of the floor of the middle fossa. When sharply punched out holes are present in this region the technique is not difficult, but the demonstration of slight changes in the foramen ovale and the moth-eaten appearance in the sphenoid bone requires patience and skill.

Examples of involvement of all of the cranial nerves have been reported as indicated in Table 1, but most authors have never seen a true eighth nerve palsy. This is explained by the fact that this nerve passes from the brain immediately into the petrous portion of the temporal bone and does not enter the neck. The location of the auditory foramen on the back of the petrous ridge also affords some protection. The seventh nerve, which passes through the same foramen, and the other posterior nerves are frequently involved outside the cranial vault. This type of damage will be discussed later. Since the sixth nerve is in the lowest position of all those that pass through the sphenoid fissure and since the gasserian ganglian and the branches of the fifth nerve lie directly over the bony structures that are first invaded, their high incidence of involvement is not surprising. The olefactory nerve rarely comes into the picture because of its anterior location. It is interesting to note that the nerves serving the eye (with the exception of the sixth), the jugular foramen group and the hypoglossal nerve are involved with about equal frequency.

TABLE I

		Cranial Nerves Involved											
Author	Cases	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Woltman	79	0	5	4	4	17	18	1	0	6	3	3	5
Fustenberg	40	0	2	4	4	5	8	3	1	1	1	0	1
Hansel	17	0	3	4	3	4	5	2	0	3	3	3	4
Needles	35	2	2	8	5	10	14	2	0	4	3	4	4
Totals	171	2	12	20	16	36	45	8	1	14	10	10	14

The following tabulation of symptoms produced by cranial nerve pressure may be of some value to the radiologist who is not familiar with neurological manifestations:

First.	Loss of sense of smell.
Second.	Loss of vision.
Third.	Ptosis of upper lid, external strabismus.
Fourth.	Diplopia.
Fifth.	*Motor root*—Loss of power of mastication. Lower jaw thrust forward and to weakened side.

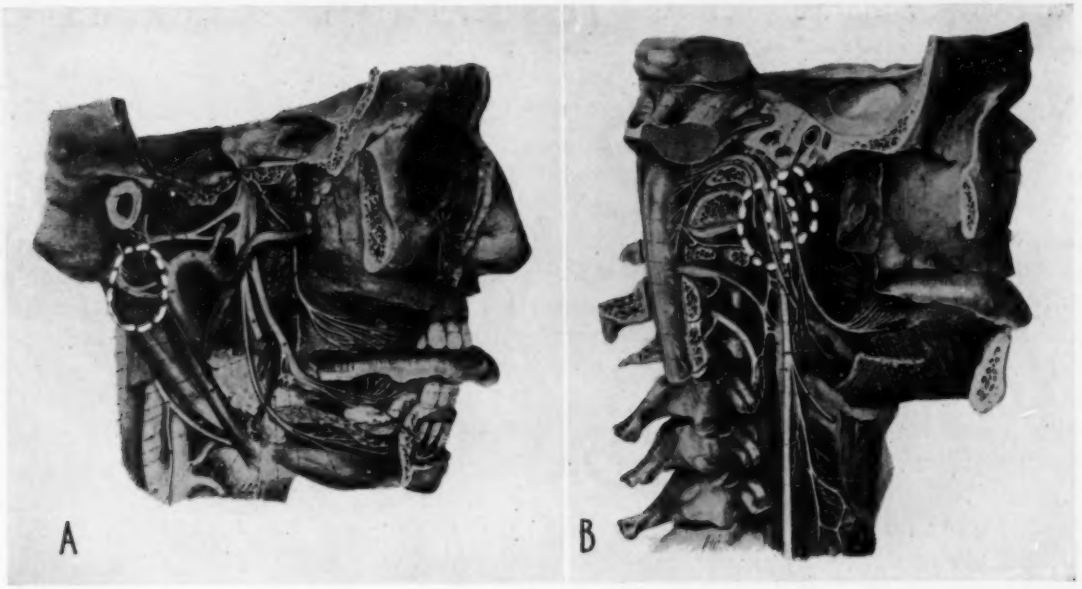

Fig. 1. *A*, location of metastatic mass in upper cervical region which causes pressure on the 7th nerve just as it leaves the mastoid process and produces facial paralysis. *B*, location of deep-seated retropharyngeal metastatic glands which press on the 9th, 10th, 11th and 12th cranial nerves and on the sympathetic trunks in the upper cervical region to produce the jugular foramen syndrome, deviation of the tongue and Horner's syndrome.

	Sensory root—Pain or loss of sensation in face, eyeball, nose, teeth or anterior tongue. Ulceration of eyeball.
Sixth.	Internal strabismus.
Seventh.	Paralysis of face. Inability to look up, frown, close eyes or show teeth. Loss of taste in anterior tongue.
Eighth.	Nerve deafness, tinnitus, vertigo.
Ninth.	Difficulty in swallowing. Loss of taste in posterior third of tongue.
Tenth.	Uvula drawn to healthy side. Paralysis of vocal cord.
Eleventh.	Inability to rotate head. Prominence of vertebral border of the scapula. Backward rotation of arm lost.
Twelfth.	Deviation of tongue to affected side.

A study of the tables makes it evident that the patient with beginning intracranial involvement usually complains of double vision resulting from interference with the innervation of the muscles of the eye and pain or anesthesia in the face, nose or teeth.

LYMPH NODE INVOLVEMENT

The first lymph nodes to enlarge are felt high up in the neck behind the angle of the jaw and a little later the submental group may become palpable. The adenopathy increases rapidly, is often accompanied by pain and a wry neck, and produces the clinical picture of Hodgkin's disease for which it is frequently mistaken. Since in 42 per cent of the 194 cases in New's group enlarged cervical lymph nodes constituted the first symptom noted by the patient, the reasoning of the physician making this mistake is easily understood. Metastatic lymph nodes are more frequent with carcinoma than with lymphosarcoma but they appear eventually in most of the untreated patients. Needles observed enlarged glands in 25 of his 35 cases.

Figure 1 indicates the proximity of the ninth, tenth, eleventh and twelfth cranial nerves to the sides of the pharynx, and it is evident that either enlarged nodes or direct extension of tumor tissue might produce pressure on these structures thereby inaugurating the symptom-complex known as the jugular foramen syndrome. The syndrome is characterized by the nasal regurgitation of fluids, dysphagia of solids and hoarseness; and is usually produced by

pressure exerted in the space bounded by the cervical spine, lateral pharynx, base of the skull and parotid gland by enlarged retropharyngeal lymph nodes. Although the twelfth nerve does not pass through the jugular foramen it lies in close proximity to the jugular group in the neck, and a deviation of the tongue is frequently observed along with the symptoms just described. The cervical sympathetic chain is also included in this collection of nerve trunks, and the foregoing symptoms may be accompanied by a narrowing of the palpebral fissure, enophthalmus and a contraction of the pupil, the so-called Horner's syndrome. Although the seventh nerve passes from beneath the mastoid upwards through the parotid gland in a more lateral location, it may also be paralyzed by a large mass of glands growing beneath the mastoid. However, facial paralysis is slightly less common than the jugular syndrome.

GENERALIZED METASTASES

Before the advent of efficient radiation therapy, these patients usually died from the effects of the primary tumor and its extensions to neighboring structures. However, during the past few years we have been struck by the frequency with which metastatic tumors appear in the mediastinum and the adjoining lung tissue after the disappearance of the lesions in the throat and neck. These extensions are likely to become evident in three to six months after treatment of the throat and produce pain in the chest, non-productive cough and loss of weight. They are readily demonstrated in roentgenograms and respond to treatment, but unfortunately abdominal metastases usually develop before the patient comes in for treatment of the chest. The more distant lesions have been reported in the stomach, mesenteries, kidneys, spleen and spine.

PULMONARY OSTEOARTHROPATHY

When Case III was observed to have clubbed fingers, together with swollen feet, hands, and knees, the condition was thought to be incidental and no roentgenograms of the extremities were made. However, when Case VI came in with identical findings, films of the arms and legs showed periosteal elevation and calcification with multiple laminations in some instances, along the shafts of both the long and the short bones. These findings, together with the clubbing of the tips of the fingers and toes, seemed to justify the diagnosis of pulmonary osteoarthropathy. No evidence of heart or lung disease or any other causes of anoxemia could be detected. Freund[3] has recently reported a case with somewhat similar bony changes in which there was no evidence of anoxemia, and he suggests that the bone lesions are produced by some toxic substance in the blood. Patients with carcinoma of the pharynx develop a severe anemia with cachexia and malnutrition and one can only hazard a guess at the possible relationship between the generalized bone changes and the toxemia produced by the neoplasm.

The following case histories illustrate many of the complications described above:

REPORT OF CASES

Case I. F. A., male, white, aged thirty-four, came to Baylor Hospital complaining of double vision and a disturbance of sensation in his face. Fourteen months before admission he developed deafness in the right ear. The eustachian tube was blown out, the ear drum was opened and the sinuses were operated on by his home physician without relief. Two months later he lost sensation in the right side of the face and right side of the tongue and within three weeks sensation disappeared in the left cheek. Four months from the time of onset, the left eye turned inwards and within a month he had a double internal squint. Two months later he began to have severe hemorrhage from the nose and mouth and his home physician could not stop them. Six months before admission he went to the Mayo Clinic where a diagnosis of epidermoid carcinoma of the pharynx, Grade 4, was made and roentgen and radium therapy was administered.

At admission he still had some radium reaction in the pharynx and as a result was complaining of pain in the throat. Both eyes were

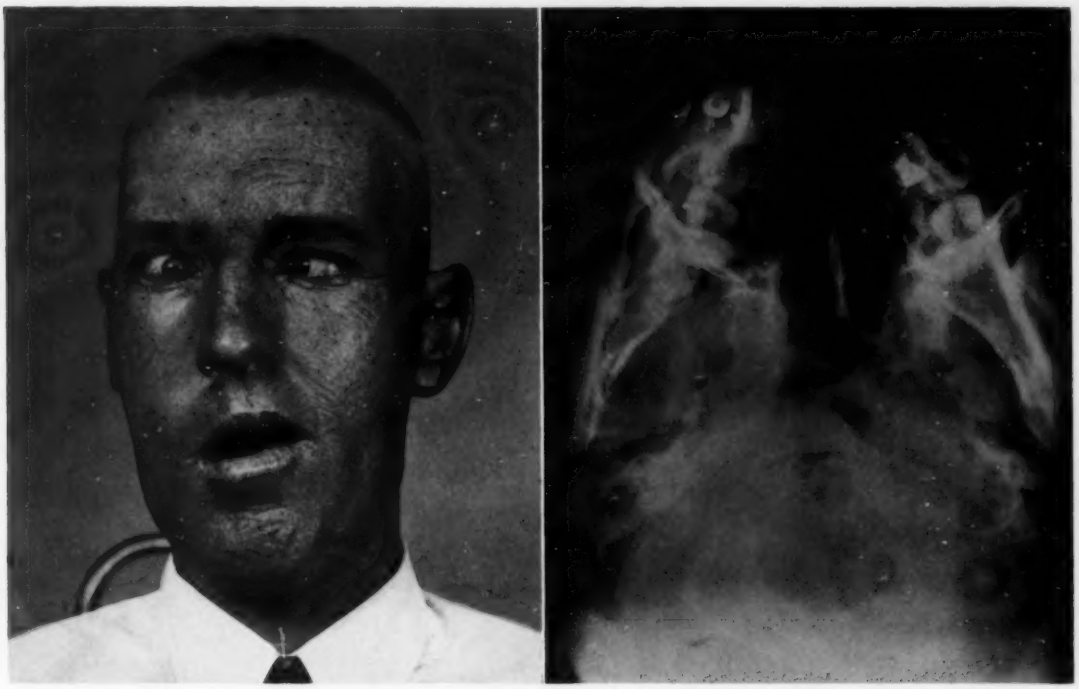

Fig. 2. Case 1. Appearance of the patient who had involvement of the 5th, 6th and 7th intracranial nerves from extension of a carcinoma of the pharynx through the floor of the middle fossa as indicated in the vertical view of the skull.

turned inwards, the left being worse than the right, and there was a loss of sensation in both cheeks and the right side of the tongue. Roentgenograms of the skull showed a partial destruction of the posterior horns and the floor of the sella turcica and floor of the middle fossa. Areas measuring 15 cm. on a side were laid out in both temporal regions so as to cover the base of the skull and received 300 r on alternate days until 2,400 r had been given to each side. The factors used were 220 kv., 20 ma., a target-skin distance of 50 cm., and a filter of 0.8 mm. of tin, 0.25 mm. of copper and 1.0 mm. of aluminum. Two months later he had gained 7 pounds and his general condition was better, but the changes due to the intracranial nerve involvement showed no improvement.

Five months after his first admission he returned complaining of partial paralysis of the muscles of the lower jaw. There were several hard glands in the submental area. No glands had been felt in the neck at previous visits. A second series of roentgen treatments was given, using the same factors as before, but three portals of entry were utilized. A circular area 7 cm. in diameter was added to the two temporal portals, and the central beams were all directed to the base of the skull. Treatment was continued over a period of twenty-seven days and each area received 2,400 r, measured in air. For four months following this treatment he felt better and intracranial changes showed no progress. He then began to suffer from constipation and attacks of abdominal distress, and complained of difficulty in swallowing. He returned to the hospital thirteen months after his first admission in a stuporous condition. He was unable to swallow, and although he received tube feeding and intravenous glucose he died in two days.

Post-mortem examination showed the floor of the middle fossa, the sphenoid sinuses and the sella turcica to be soft and spongy and partially destroyed by a "transitional cell carcinoma" which apparently had been primary in the upper pharynx. The tumor surrounded the sella turcica and passed backwards between the dura and the skull producing many implants in the dura. No metastases were found in the neck or any other portion of the body.

Case II. A. R. C., female, white, married, aged twenty-two, came to the hospital complaining of double vision, photophobia, head-

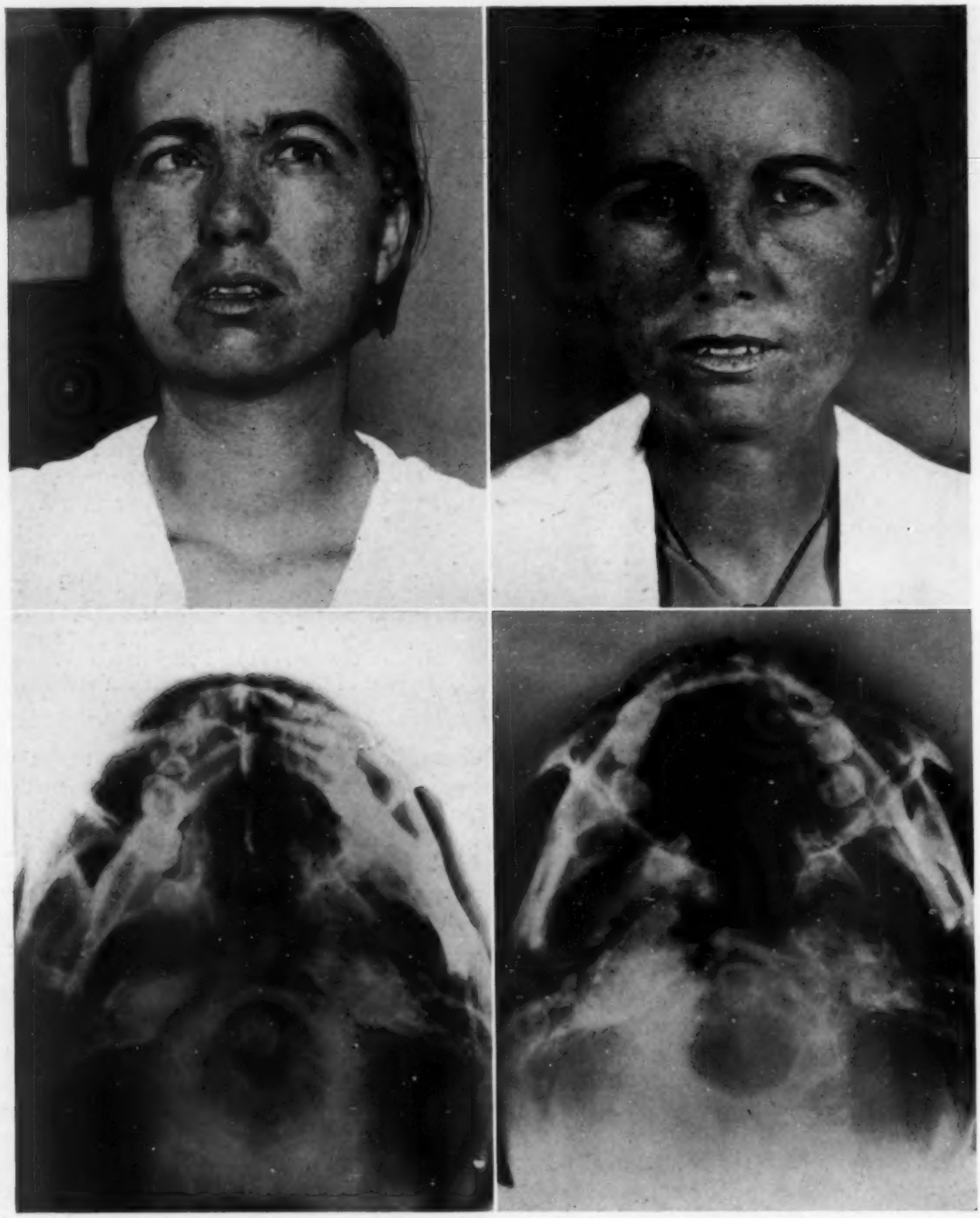

Fig. 3. Case 11. Appearance before and after intensive roentgen treatment of the base of the skull. The photograph on the left shows a right-sided internal strabismus due to extension of a carcinoma of the pharynx through the floor of the middle fossa with erosion of the tip of petrous portion of the temporal bone. After treatment the eyes are straight and regeneration is seen in the petrous tip.

ache and loss of weight. For one year she had noticed a swelling of both jaws and a twitching of the right upper eyelid. Eight months before admission she developed double vision and a purulent discharge from the nose. Her dentist removed a number of her teeth without relief and she soon found that she could open her mouth only part way. Her home physician re-

moved some tumor tissue from the nasopharynx at this time but it was not examined histologically. She continued to grow worse and consulted Dr. T. E. Fuller of Texarkana two months later. He discovered a friable bleeding tumor filling the right side of the pharynx and extending across to the opposite side. Although no biopsy was done roentgen therapy

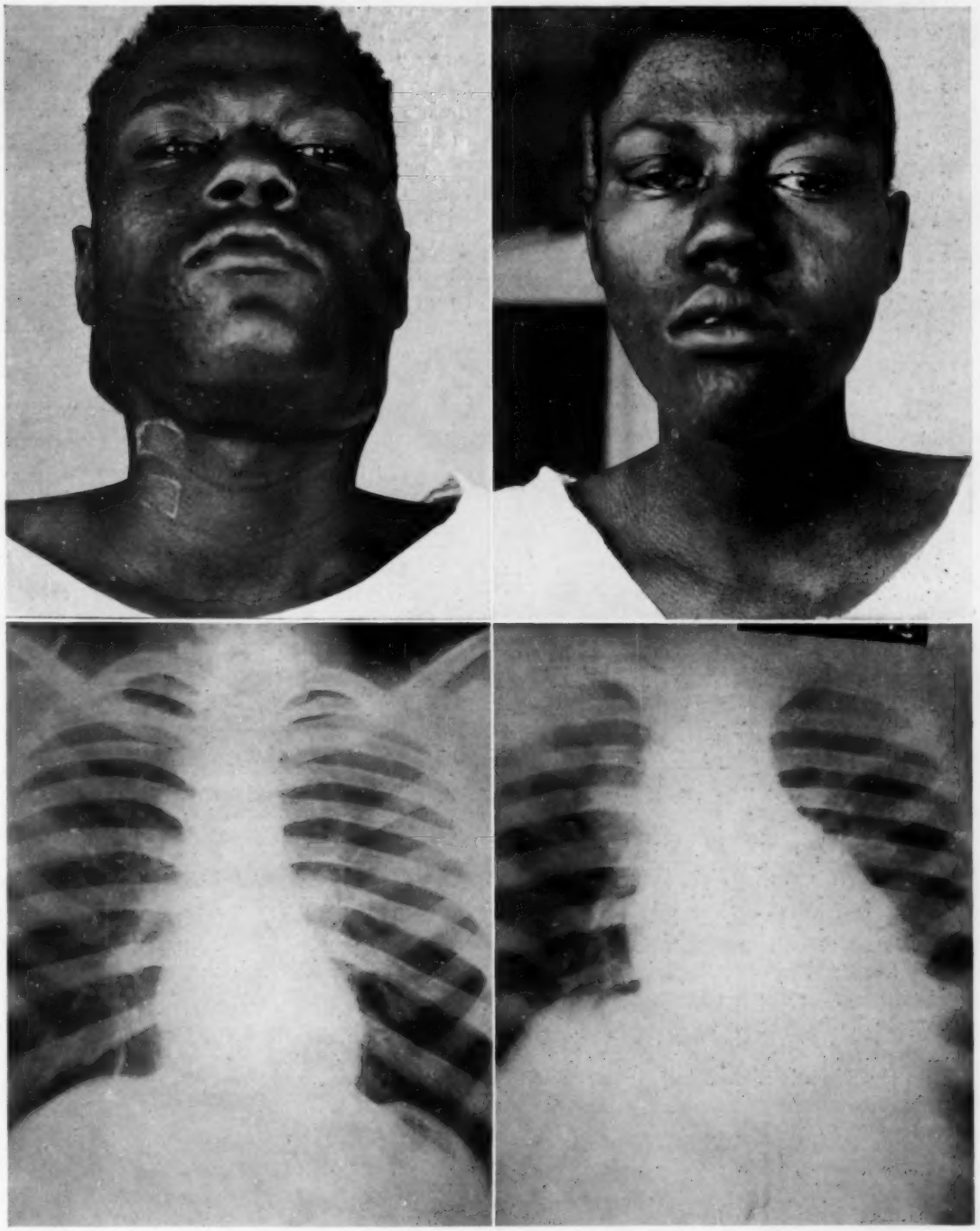

Fig. 4. Case III. Extensive lymph node involvement in upper cervical and submental regions secondary to a carcinoma of the pharynx. The chest had a normal appearance at the first visit, but when the patient returned after five months the heart was enlarged because of metastatic nodes in the upper mediastinum. This complication occurred after the pharyngeal and cervical lesions had completely disappeared.

was advised, and 2,500 r was given to each side of the pharynx through portals measuring 10×12 cm. during a period of three weeks by Dr. Harrell. She was quite nauseated at this time and although the throat showed marked improvement she continued to decline and lost a total of 30 pounds in weight.

At admission the patient was poorly nourished and kept her right eye closed because of a marked photophobia. Dr. Sellers reported much scarring in and about the fossa of Rosenmüller on the right side, but a biopsy from this region revealed no tumor tissue and none could be found anywhere in the pharynx. Neurological examination revealed a paralysis of the 4th and 6th nerves on the right side with a partial involvement of the 5th. The posterior cranial nerves were not involved. Roentgenograms of the skull taken in the vertical position showed a sharply defined oval area of destruction in the base of the skull measuring about 1 inch in diameter and surrounding the tip of the petrous portion of the temporal bone.

Areas measuring 10 cm. on a side were laid out in each temporal region with their anterior edges placed just posterior to the lateral edges of the orbits. These areas were centered over the petrous portions of the temporal bones. Each area received 300 r (measured in air) every second day (except Sunday) until a total of 3,000 r had been delivered to each side. The machine was operated at 220 kv., with 20 ma., a filter of 0.8 mm. of tin, 0.25 mm. of copper and 1.0 mm. of aluminum and a target-skin distance of 50 cm.

Three months later she returned feeling much better, was free of pain and had gained some weight. She still had a squint and double vision but the photophobia had cleared up. There was some tingling in the right cheek.

After another three-month period she looked well but complained of dizziness and showed a tendency to fall to one side when walking with her eyes closed. Since these signs suggested posterior fossa involvement, daily doses of 300 r were administered to an area measuring 15×10 cm. and centered over the occiput until 3,000 r had been given. The factors were the same as those used at the first visit.

Following this therapy steady improvement occurred. Thirteen months have now elapsed since the first series and she has gained back the 30 pounds lost and feels well and strong. All of the signs have disappeared except a slight internal squint in the right eye. However, she no longer sees double and is able to take care of her household duties without difficulty.

Case III. N. T., a negro boy, aged nineteen, came to the Baylor Tumor Clinic because of marked malaise, hemorrhage from the nose and large glands in his neck. For two months he had suffered from recurrent nasal hemorrhages and during the same period the glands in the sides of his neck had enlarged rapidly. At admission the boy was quite ill and examination showed the upper posterior pharynx to be filled with friable bleeding tumor tissue which protruded into the nasal passage. Microscopic studies of this tumor showed it to be a transitional cell carcinoma, Grade 3. The hands, feet and knees were large and swollen and the tips of the fingers were clubbed. Unfortunately, no films of the extremities were made. Very large hard glands were felt in the submental areas and beneath the angles of both jaws. Films of the chest showed no involvement of the lungs or mediastinum. No signs of intracranial disease could be detected.

Areas 15×15 cm. were laid out to include the enlarged nodes and the pharynx on each side and 300 r was delivered to each area on alternate days until 2,950 r had been administered to each side. The factors were 220 kv., 20 ma., a target-skin distance of 50 cm., and a filter of 0.8 mm. of tin, 0.25 mm. of copper and 1.0 mm. of aluminum.

All evidence of the disease in the throat and neck disappeared and he felt well for five months. He then returned complaining of weakness, pain in the chest and back and loss of bladder control. A film of the chest revealed a tumor mass in the upper mediastinum producing a definite cardiac enlargement. A neurological examination indicated the presence of metastases producing pressure on the lower spinal cord. Single erythema doses given over the entire spine as a palliative measure produced some improvement but he died three months later in another city.

Case IV. W. W., a well-developed male negro, aged thirty-six, came to the Baylor Tumor Clinic because of a sore throat and a swollen neck. His throat had been sore for five months and glands had been enlarging in the sides of his neck for three months.

Examination showed the upper pharynx to be filled with friable tumor tissue which proved to be transitional cell carcinoma when sections

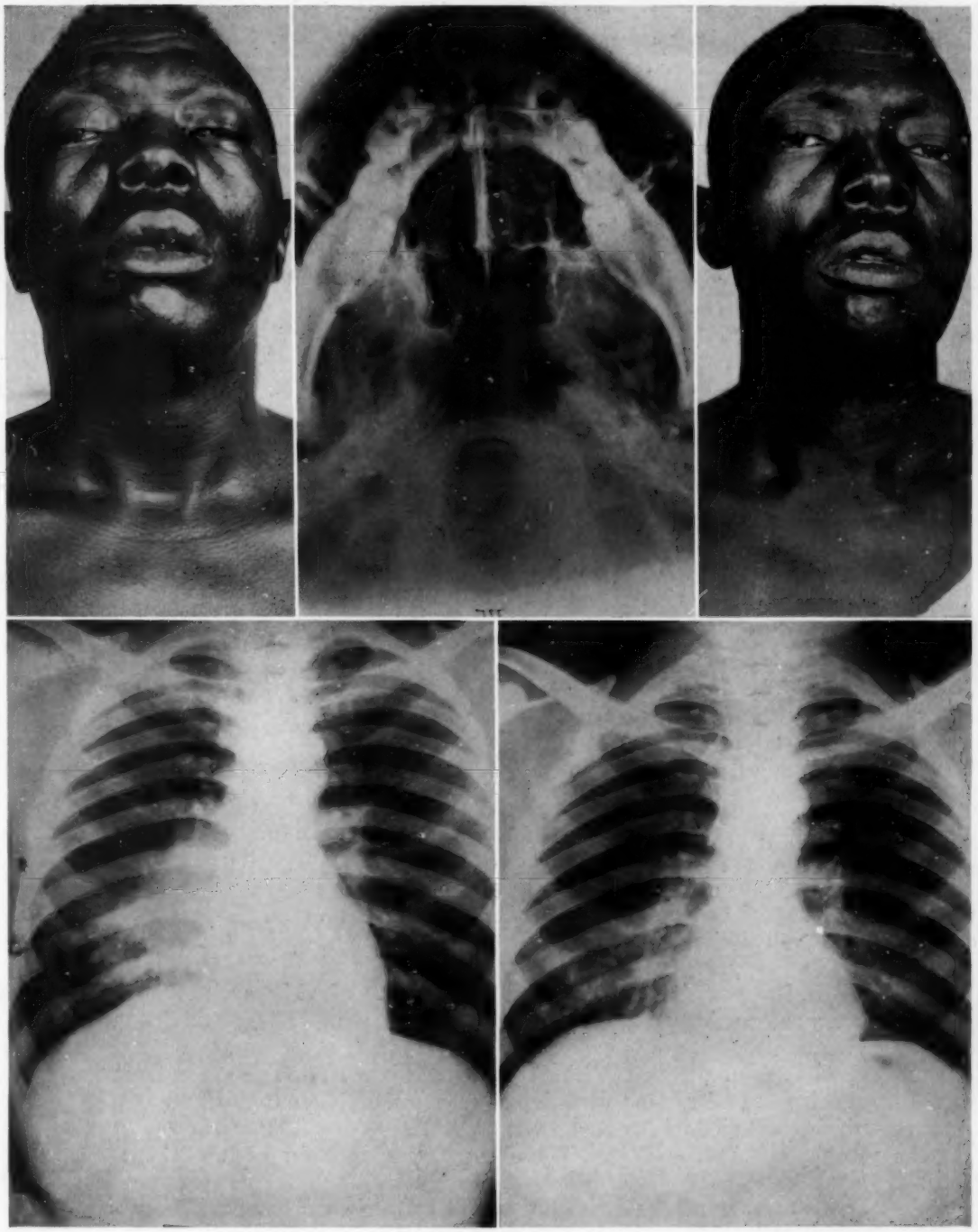

Fig. 5. Case IV. The upper photographs show the complete disappearance of swelling of the face secondary to metastatic lymph nodes after roentgen therapy. The tumor did not invade the floor of the skull. The lower roentgenograms show the resolution of a metastatic tumor at the right lung root which appeared three months after the structures above the clavicles were clear of disease.

were studied. Masses of hard, markedly enlarged lymph nodes were observed in the upper posterior triangles of the neck on both sides. He had no signs of intracranial nerve involvement. Films of the skull showed no evidence of bone invasion. Films of the chest showed no involvement of the lungs or mediastinum.

Areas 15×15 cm. were laid off on both sides

of the neck so as to include the pharynx and the involved lymph nodes, and 300 r was administered to each side on alternate days until 3,000 r (measured in air) had been delivered to each area. The factors were 220 kv., 20 ma., a target-skin distance of 50 cm. and a filter of 0.8 mm. of tin, 0.25 mm. of copper and 1.0 mm. of aluminum.

The tumor in the pharynx and the cervical nodes had all disappeared in a month but he returned in three months complaining of cough and loss of weight. Films of the chest revealed an infiltrating mass measuring 7×10 cm. at the right lung root. Areas 15×15 cm. were laid out on the front and back of the thorax directly over the involved area and 2,400 r was given to each area during a period of eighteen days, using the technique described above. Films made soon after the series was finished showed a complete disappearance of the pulmonary mass.

Fig. 6. Case v. The first photograph shows the patient as she appeared before roentgen therapy. The middle photograph made three years and eight months later shows metastatic glands in the left neck which was clear of disease at the first visit. Only a small mass of scar tissue was felt in the right neck at this time. The last photograph made six weeks after a second series of treatments shows the neck clear of disease. The primary lesion in the pharynx has not recurred.

Case v. C. P., female, negro, aged thirty, came to the Baylor Tumor Clinic because of a swollen, painful neck and difficulty in chewing. Eight months before admission she noticed a tender mass of glands growing beneath the angle of the right jaw. She consulted a dentist who was unable to relieve her. A month later pain appeared about this mass and it was referred to the ear. She then found chewing painful.

Dr. Lyle Sellers described a small primary carcinoma behind the fossa of Rosenmüller on the right side. The pathological report on a gland removed from the neck was transitional cell carcinoma, Grade 3. A 10×15 cm. area was laid out to include the pharynx and glands in the right side of the neck and 300 r was administered to this area daily (except Sunday) until 3,900 r had been given. The factors were 200 kv., 6 ma., a target-skin distance of 50 cm., and a filter of 0.75 mm. of copper and 1.0 mm. of aluminum. The skin showed a rather marked reaction and the tumor in the throat disappeared rapidly. The mass in the neck was reduced to a hard nodule about 2.0 cm. in diameter.

This patient disappeared from the clinic but after a period of three years and eight months she returned because of a large hard gland growing beneath the angle of the left jaw. Examination revealed her condition exactly as at her last visit except for the presence of the new gland. No evidence of intracranial or pulmonary extension could be detected.

A total of 3,600 r was delivered to an area measuring 10×15 cm. on the left side of the

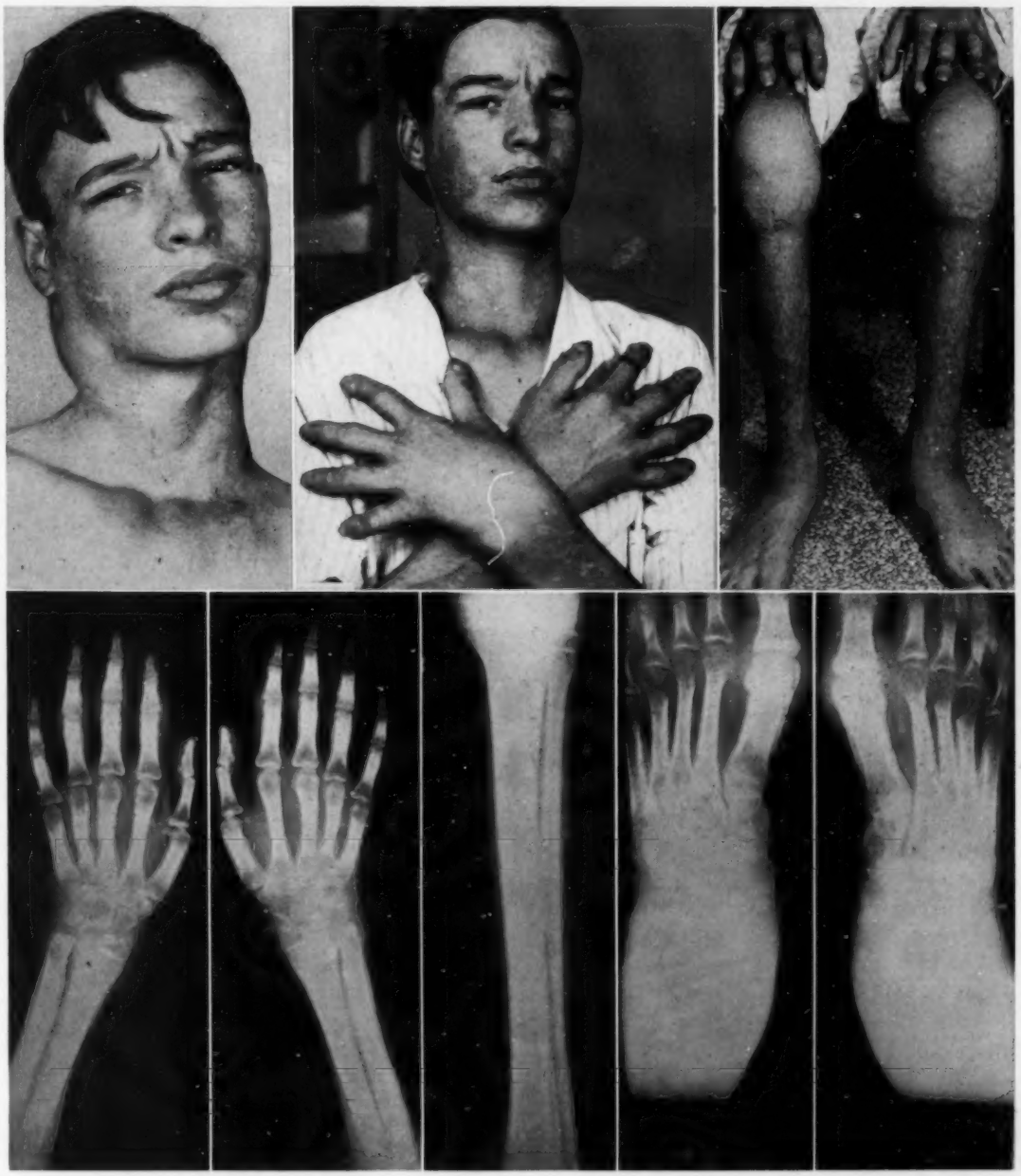

Fig. 7. Case vi. Well-developed "pulmonary osteoarthropathy" accompanying carcinoma of the pharynx with cervical metastases. Complete resolution of the malignant lesions after roentgen therapy produced no change in the bone lesions.

neck, using 300 r daily with 220 kv., 20 ma., a target-skin distance of 50 cm., and a filter of 0.8 mm. of tin, 0.25 mm. of copper and 1.0 mm. of aluminum. After a month the gland is reduced to about one-third its former size but is still present.

Case vi. A. B., a white boy, aged fifteen, came to the Baylor Tumor Clinic because of tinnitus, stiffness of the neck and loss of weight. Seven months before admission he began to hear noises in the right ear. A month later a mass of glands appeared in the neck beneath the right ear and grew rapidly, producing much pain and stiffness. Three months later glands appeared in the upper portion of the left side of the neck. He had lost 25 pounds in six months.

Examination revealed a slender, pale boy

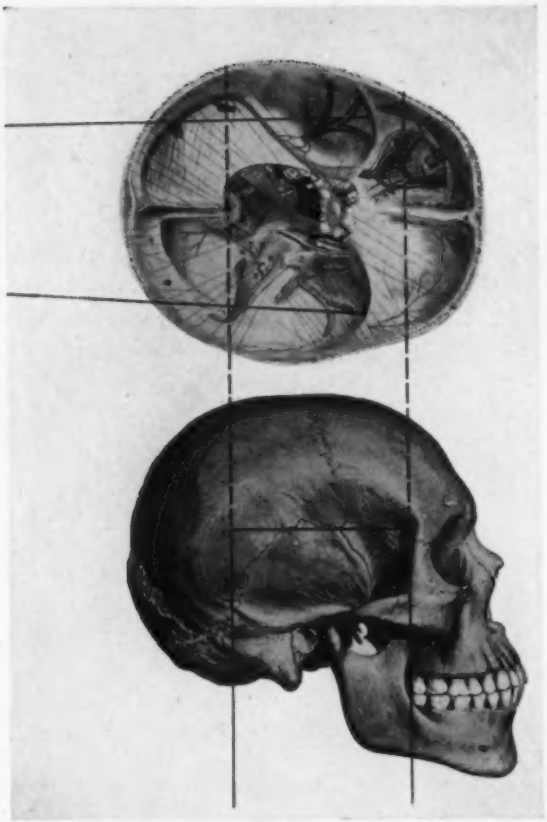

Fig. 8. Location of lateral and posterior portals for roentgen beams directed so as to include a carcinoma of the pharynx and its paths of extension into the base of the skull and the cervical lymph nodes.

who was very uncomfortable because of a large mass of glands below the right ear. Smaller glands were felt below this mass on the right side and in the upper portion of the neck on the left side. The pathological report on one of the glands removed for study was transitional cell carcinoma, Grade 2. Dr. Lyle Sellers reported a primary tumor of moderate size in the lower portion of the fossa of Rosenmüller on the right side. Little attention was paid to clubbing of the fingers and toes and a moderate swelling of hands and feet at that time.

Areas 15×15 cm. were laid out so as to include the pharynx and the glands on each side of the neck, and 3,300 r was administered to the right side and 2,700 r to the left side, using 300 r to each side on alternate days. The factors were 220 kv., 20 ma., a target-skin distance of 50 cm., and a filter of 0.8 mm. of tin, 0.25 mm. of copper and 1.0 mm. of aluminum.

All evidence of the malignant lesion in his throat and neck had disappeared in four weeks, but he returned after six months complaining of marked swelling and discomfort in the hands, feet and knees. Roentgen examinations made at that time revealed periosteal proliferation and calcification along the shafts of the long bones of the legs and arms, the clavicles, the metacarpals, metatarsals and phalanges. The fingers showed definite clubbing and the roentgen findings were those described with pulmonary osteoarthropathy. Roentgenograms of the chest showed no evidence of disease in the heart or lungs and there was still no carcinoma detected in the pharynx or neck. He died six months later in another city. The exact cause of death was not ascertained.

TREATMENT OF COMPLICATIONS

Although new radiotherapeutic techniques have improved the outlook for patients with this condition, Furstenberg reflects the pessimistic attitude of most otolaryngologists when he says: "The prognosis remains hopelessly futile." On the other side of the picture, New states that whereas the average length of life of the patient receiving no treatment is 6.8 months, the average length of life of the

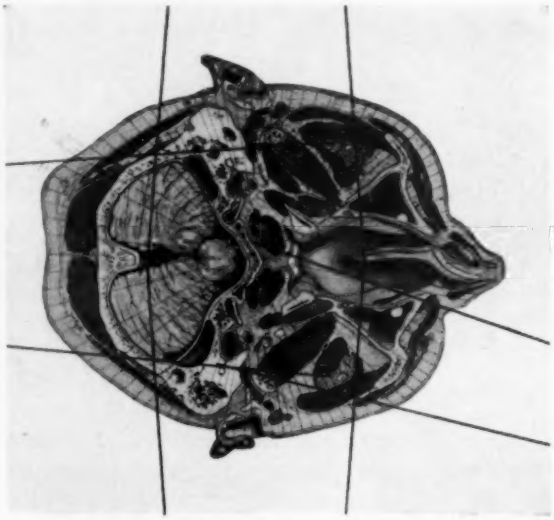

Fig. 9. Cross section of the skull cut just below the cranial vault showing how the portals of entry illustrated in Figure 8 include the posterior cranial nerves and the sympathetic trunks as they pass downwards in the neck. A small extra portal may be directed through the cheek in stubborn cases.

cases treated at the Mayo Clinic was extended to 34.4 months and one patient lived 94 months. It should also be remembered that Coutard[1] reported 10 per cent of 89 cases free of symptoms at the end of five years.

The good results obtained with the primary lesions have been reported in previous papers,[6,7] but a study of the above case reports reveals two points of interest. First, the treatment of the base of the skull was inadequate in all but one case and second, pulmonary metastases responded well to treatment but therapy was not administered in any instance until after the extension had passed on into the abdomen.

These observations suggest the following improvements in technique:

1. Areas laid out over each side of the pharynx should extend from the lateral wall of the orbit to a point ½ inch behind the mastoid and should include the base of the skull and the submental area as well as the upper portions of the triangles of the neck. The dosage given to each area should not be less than 3,000 r.

2. When the reaction from this series has subsided, a third area laid out over the base of the occipital region and the back of the neck should receive 3,000 r with the central beam directed to the base of the skull. In certain cases it may be desirable to deliver more radiation through the cheek, using a small portal and directing the beam to the side of the neck and the under side of the jugular foramen.

3. At or about the same time, 2,400 r should be delivered to the front and back of the upper mediastinum in an effort to stop the downward extension which so often occurs.

All of this treatment could be given during a period of eight to ten weeks, including the rest period. If the treatment is carried our carefully in early cases the occurrence of metastases should be definitely retarded and more permanent cures should be obtained.

SUMMARY

Malignant tumors of the nasopharynx are rarely diagnosed early. Their presence is often overlooked even when the symptoms resulting from intracranial extension, cervical adenopathy and mediastinal involvement appear. The administration of vigorous irradiation to all of the known paths of extension carried out while the lesion is still limited to the nasopharynx should improve the end-results.

REFERENCES

1. Coutard, H. Roentgen therapy of epitheliomas of the tonsillar region, hypopharynx and larynx from 1920 to 1926. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 313–331.
2. Escat, E. Maladies du pharynx. G. Carre and C. Maud, Paris, 1901.
3. Freund, E. Idiopathic familial generalized osteophytosis. Am. J. Roentgenol. & Rad. Therapy, 1938, *39*, 216–227.
4. Furstenberg, A. C. Malignant neoplasms of the nasopharynx. *Surg., Gynec. & Obst.*, 1938, *66*, 400–404.
5. Hansel, F. K. Malignant tumors of the nasopharynx with involvement of the nervous system. *Ann. Otol., Rhin. & Laryng.*, 1932, *41*, 74–93.
6. Martin, C. L. Carcinoma of the upper pharynx. *Am. J. Surg.*, 1935, *30*, 36–45.
7. Martin, C. L. Malignant tumors of the throat. *Surgery*, 1937, *2*, 381–400.
8. Needles, W. Malignant tumors of the nasopharynx. *J. Nerv. & Ment. Dis.*, 1937, *86*, 373–398.
9. New, G. B. Syndrome of malignant tumors of the nasopharynx; report of 79 cases. *J. Am. M. Ass.*, 1922, *79*, 10.
10. New, G. B. Highly malignant tumors of the nasopharynx and pharynx. *Tr. Am. Acad. Ophth.*, 1931, *36*, 39–44.
11. Oppikofer, E. Ueber die primären malignen Geschwülste des Nasenrachenraumes. *Arch. f. Laryng. u. Rhin.*, 1913, *27*, 256.
12. Woltman, H. W. Malignant tumors of the nasopharynx with involvement of the nervous system. *Arch. Neurol. & Psychiat.*, 1922, *8*, 412.

DISCUSSION

Dr. H. B. Hunt, Omaha, Nebr. Dr. Martin's excellent paper on carcinoma of the nasopharynx has correlated the anatomic, pathologic, and clinical manifestations of this lesion

in an admirable way. We, ourselves, have been misled in the diagnosis of two nasopharyngeal tumors recently. The first case was misdiagnosed as a possible cerebellopontine angle tumor, explored, and nothing was found. Further subsequent review of the films with particular reference to the nasopharynx showed a unilateral tumor encroaching upon the airway and decalcifying the base of the skull, as shown by the mentovertical projection. The lesion was radioresistant and a biopsy was interpreted as a neurogenic fibrosarcoma.

The second case was misdiagnosed as cervical adenitis and hyperplastic sinusitis with polypi filling the nasopharynx. Two recent intranasal operations had been done for relief of the obstruction, without examination of the tissue removed. A lateral sinus film showed a tumor in the adenoid area which had rapidly increased in size during a few weeks. It had closed off the airway and displaced the soft palate downward. We believe this rapid growth of nasopharyngeal tissue should always suggest the possibility of a malignant tumor. The nasopharyngeal tumor and cervical metastasis receded rapidly under treatment, although the patient subsequently developed a sixth nerve palsy, proptosis, and blindness in one eye. A second series of treatments relieved the proptosis and palsy, but the blindness remained due to damage of the retina by prolonged ischemia from pressure on the optic vessels. He has recently developed mediastinal metastasis.

These experiences emphasize the importance of always bearing in mind the possibility of a malignant tumor of the nasopharynx in cases of nasal obstruction or symptoms involving the fifth to seventh cranial nerves, and the importance of thorough extensive initial treatment, as also outlined by Dr. Martin.

I believe that the average radiotherapist is unduly pessimistic with regard to carcinoma of the esophagus. The lesion is anatomically well adapted to treatment by means of eight or ten beams of radiation converging like the spokes of a wheel. A dosage of 1,500 to 2,500 r can be delivered per portal in three to five weeks. The esophageal lumen will open in many cases. If the patient has lost weight, preliminary gastrostomy may be indicated. In the event of secondary occlusion of the esophagus by irradiation fibrosis, gastrostomy may subsequently be required in other cases.

Dr. Martin (closing). I would like to emphasize the importance of roentgenograms of the skull where cranial nerve damage from pharyngeal neoplasms is present. Even when the tumor has entered the cranial vault, experienced otolaryngologists sometimes have difficulty in locating the primary lesions which may be quite small.

Vol. 41, No. 3

ANALYSIS OF END-RESULTS FOLLOWING EXPERIMENTAL RADIATION THERAPY OF GASTRIC CANCER

A REPORT OF 268 CASES*†

By GEORGE T. PACK *and* GORDON McNEER
NEW YORK CITY

THE first report of a carcinoma of the stomach to be treated by roentgen therapy was by Despeignes[3] in 1896. He treated a patient by this method shortly after Roentgen's discovery of the x-rays; it was the first cancer in any region to be treated by roentgen therapy. The lesion was subjected to 80 exposures of the roentgen rays, each of some fifteen to thirty minutes' duration, twice a day.

Not until 1914 were any other instances of this kind of treatment described. Then Wickham and Degrais[14] inserted radium into the stomach of a patient with pyloric cancer, after a preliminary gastroenterostomy had been performed, leaving an opening in the distal part of the stomach for the purpose. The radium was inserted by means of a catheter toward the pylorus. This was continued over a period of three months during which a simultaneous course of external irradiation was given to the palpable tumor through the abdominal wall. This patient, like the one described by Despeignes, is said to have been symptomatically improved by the treatment.

Janeway,[6,7,8] in 1918, treated a patient also by inserting radium into the cavity of the stomach after the organ had been opened. The tumor apparently decreased in size and the patient was sufficiently improved subjectively to cause Janeway to consider it justifiable to treat 6 other patients by the external application of radium.

In 1922, Levin[9] recommended the insertion of bare glass capillary tubes of radon into gastrointestinal and retroperitoneal cancers, but disapproved of the use of external radium irradiation because of the severe cachexia said to be caused thereby. He regarded the external use of radium as ineffectual.

High voltage roentgen rays were tried by Evans and Leucutia[1] in 25 patients with gastric cancer reported in 1923. Two cancers disappeared after treatment but recurred within eight and twelve months. These authors particularly advocated that the lungs and adrenal glands be avoided by projecting films of the kidneys and stomach on the body to help mark the fields and tilt the tube correctly. The dosage to the organ was from 110–130 per cent of a skin erythema dose through several portals, cross-firing at the tumor. They found that 140 per cent skin erythema dosage was the maximum tolerated without damage of the intestinal mucosa. In conjunction with this treatment they kept the patients on a fat and acid-free diet and administered an abundance of alkalies, plus cerium oxalate and essence of pepsin for radiation sickness.

Scholz[12] conceived the method of irradiating the stomach when filled with barium, and tried it in a patient who had had a gastroenterostomy for an inoperable carcinoma. The patient was well seven years after this irradiation, and roentgen examination revealed a normal stomach. However, the malignant character of the tumor was attested to only by the visual observation of the surgeon at operation. No biopsy was performed. Therefore, it is by no means certain that this was a successfully treated cancer and the results do not supply a rational basis for irradiating the barium-filled stomach. Moreover, the secondary rays produced by the contact

* From the Memorial Hospital for Cancer and Allied Diseases. Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.
† Aided by a grant from Mr. Lucius N. Littauer.

of roentgen rays and barium are not deeply penetrating and therefore could not affect more than the surface of the tumor. However, the technique might be justifiable if the cancer could be thoroughly impregnated with a heavy metal or its salts. But with our present technique of fractionated dosage, requiring daily treatments over three weeks, the patient would have to ingest a dangerously large amount of barium.

Werner,[13] in 1925, particularly stressed the necessity of a prior operation in which the gastric tumor would be fixed to the anterior abdominal wall in order to make it more accessible to irradiation, but the requirements for such a procedure were that the tumor be movable and not too deeply seated. Irradiation was begun a few days after the operation, $\frac{1}{2}$ to $\frac{3}{4}$ skin unit in divided doses being given, care being taken to avoid too rapid breaking down of the tumor. Werner advised repetition of the small doses after from four to six weeks, but with an increase of the dose for relief of pain in the very advanced case. Werner's recommendations were made after he had found the external application of radium to be ineffective.

The largest series of cases has been those reported by Schmidt,[11] in 1928, Holfelder[4,5] in 1929 and in 1931, and Gosset, Monod and Regaud[2] in 1933. The last named authors found that of 31 gastric cancers treated by radium 7 were definitely improved symptomatically, but did not benefit by prolonged survival. In 17 there was neither amelioration of symptoms nor increased length of life. The cancers most amenable to this form of therapy were locally recurrent tumors after gastrectomy.

We have tested out Holfelder's recommendation of the use of a compression diaphragm to exclude the organs overlying the tumor by pressure and replacing with air as much as possible the distance between the target and the tumor. Whereas theoretically this procedure brings the skin nearer to the tumor and accounts for a relatively greater depth dose, actually the increased dose thus administered is but a small fraction of one skin erythema dose and scarcely worth the effort. A similar effect is obtainable by the employment of pressure cones.

In 1935, one of us (Pack) in association with Scharnagel, Quimby, and Loizeaux,[10] estimated that 10 per cent of gastric cancers may be classified as radiosensitive and that a greater percentage will respond in some degree to well-planned radiation therapy. Non-resectable cancers obstructing the cardia or the pylorus are best treated by gastrostomy and gastrojejunostomy respectively, but if these procedures are contraindicated by the patient's age or physical condition or when one cannot obtain consent for operation, radiation therapy has in some cases given temporary relief from obstruction. There is a certain anaplastic small cell gastric cancer which bears a close morphologic resemblance to lymphosarcoma which is most sensitive to irradiation. If the tumor is of an anaplastic or radiosensitive variety, it is well to follow gastric resection by a well-planned cycle of high voltage roentgen treatments or by application of a radium element pack externally at a distance. We use a large field of irradiation. Irradiation may be instituted within two weeks after an operation without danger of impairing the healing of the wound. For ordinary cancers of the stomach (fibrocarcinomas, malignant adenomas, Grade 2 adenocarcinomas and gelatinous adenocarcinomas) postoperative prophylactic irradiation has not proved worth while in our experience.

Improvement is estimated clinically by the patient's ability to swallow food, in the instance of involvement of the cardia, or by the diminution in gastric residue after six to twenty-four hours, as noted by roentgenograms made after the ingestion of a barium sulphate meal. In those cases in which short-circuiting operations are possible, irradiation has given occasionally favorable results as a supplementary palliative procedure. Our first report of 60 inoperable gastric cancers, the majority of which were situated in the proximal half

TABLE I

END-RESULTS OF RADIATION THERAPY FOR GASTRIC CANCER

Year of Report	Author	No. of Patients Treated	Method	Improvement	
				Subjective	Objective
1896	Despeignes	1	Roentgen exposure	Pain disappeared	
1914	Wickham and Degrais	1	Insertion of radium after gastroenterostomy	For 18 mo.	Reduction size of tumor
1918	Janeway	7	6 by external irradiation; 1 by insertion of radium after gastroenterostomy	Slight	
1922	Levin		Treatment given by insertion of bare glass capillary tubes of radon twice through two different laparotomy wounds	Roentgen and radium externally, ineffective; improvement in some cases with author's method	
1923	Evans and Leucutia	25	High voltage roentgen rays	All symptomatically relieved	In 2, the tumor disappeared for 8–12 mo.
1923	Cahen	2	External radium therapy; moulages	Symptomatically improved for 10 mo.	
1928	Schmidt	30	Roentgen therapy	1 lived for 3 yr.	
1929	Holfelder	2	Roentgen therapy	1 lived 2½, 1 lived, 1 yr.	Tumor disappeared in both
1931	Holfelder	100	Using compression diaphragm to exclude organs overlying tumor by pressure	2 lived 1 yr., 2 for 6 mo.	
1932	Scholz	1	Irradiation of barium-filled stomach after gastroenterostomy	Well for 7 yr.	Normal stomach on roentgen examination
1933	Yeomans	1	Gastroenterostomy plus interstitial irradiation by gold radon seeds		
1933	Gosset, Monad and Regaud	31	Gamma rays more effective therapeutically than roentgen rays; treatment limited to external application of radium	17, no improvement; 7, improved with noticeable prolongation of life; 1 cured 6½ yr. 1 for 33, 1 for 11, 1 for 12, 1 for 16 and 1 for 21 mo.	
1935	Pack, Scharnagel, Quimby and Loizeaux	60	External irradiation with high voltage roentgen rays and radium element pack; interstitial irradiation using gold radon seeds	1 (with lymphoma) living 6 yr. after treatment, well; 1 for 3 yr.; 2 for 2 yr.; 6 were relieved for a short time, but succumbed to recurrent activity, or residual cancer, or to distant metastasis; of these, 1 lived 20 mo., 1 for 18 mo.	
1937	Pack and McNeer	268	Same technique as above	Twenty per cent of patients received worth while palliation; 5 per cent of patients obtained excellent benefit (see text)	

of the stomach, treated by irradiation, gave the following end-results; One patient (with gastric lymphosarcoma) was living and well six years following irradiation, 2 others were without evidence of gastric cancer after an interval of two years, and in 6 patients the treatment had palliative value, though all 6 later succumbed to recurrent cancer or to distant metastases. One of these patients lived for twenty months and gained 45 pounds in weight, following radiation therapy for a bulky carcinoma on the greater curvature of the fundus. Another patient, a man aged forty, with a carcinoma occluding the cardiac orifice, was able to carry on manual labor for a year and one-half following treatment.

The disadvantages of irradiation of gastric cancer are: (*a*) the necessity for daily utilization of the stomach in feeding; (*b*) the inaccessibility of the stomach and the consequent low tissue dose delivered by external irradiation; (*c*) the degree of radiation sickness, following treatment; (*d*) the extent of the cancer, as only inoperable cancers are treated by irradiation, and (*e*) the frequent obstruction of the cardia and pylorus by these cancers.

Even with the advantage gained by divided and protracted treatment in favorable cases, the quantity of radiation which it is possible to deliver by external irradiation to the average cancer of the stomach within a reasonable time is considerably less than that which has been found necessary to produce regression of various carcinomas in other parts of the body. In certain cases, it is possible to supplement external irradiation by the interstitial implantation of radium. For rather small, accessible, circumscribed cancers, this type of treatment seems to be ideal. The radiation is delivered exactly where it is needed: the tumor cells receive more than the normal cells; unaffected organs are, in general, far enough away not to be damaged, and the systemic reaction is minimized.

Since the previously mentioned report, the present authors have surveyed all cases of gastric cancer treated by irradiation at the Memorial Hospital.

METHODS OF IRRADIATION FOR GASTRIC CANCER

External Irradiation by Roentgen Rays. Before starting treatment, the patient is roentgenoscoped after the ingestion of a barium meal, in order to locate the tumor. This procedure is carried out with the patient in lateral, prone and supine positions so that the exact location of the tumor is projected on the skin and outlined in indelible ink. The skin portals for irradiation are centered over these markings, so that the beam is directed towards the center of the tumor. The portals are made somewhat larger than the tumor, but not large enough to include the surrounding vital tissues. Four portals, the right and left anterior and posterior, have been used for cancers in the distal segment of the stomach. Tumors of the gastric cardia and fundus are more accessible to irradiation delivered through three left upper abdominal portals, namely, left anterior, lateral and posterior fields. If the patient is obese, as many as five portals may be outlined around the left upper abdomen. The usual size for each portal is 12×14 cm. or more.

From 1918 until 1928, patients with gastric cancer were treated at the Memorial Hospital by low and high voltage roentgen radiation, in cycles consisting of one treatment to each skin portal at two to four day intervals. Each treatment was of 750 to 800 roentgens. This cycle was repeated after ten or twelve weeks. The dose delivered to the tumor by this technique was comparatively very small. The principles underlying the employment of all the factors governing external irradiation were not fully appreciated; nor were there available roentgen machines capable of such treatment as are provided today. The principle of fractionated doses was not employed at this institution until 1928; and even then the total doses attained were far less than those realized at present, and except for one unusual end-result,

there was little change in the degree of palliation secured by this treatment.

In 1931, a separate gastric service was organized for treating patients with gastric cancer. Operable gastric cancers are treated by gastric resection, a method of treatment which our past and present experiences with irradiation would indicate is the preferable method of treatment for cancers in the strictly operable group. Radiation therapy has been reserved as the treatment of choice for gastric cancers which are inoperable because of their extent, fixity or location in the cardia or fundus.

The standard method of roentgen treatment, in use since 1931, has been the utilization of 200 kv. (peak), a target-skin distance of 70 cm., a filter of 0.5 mm. of copper and 1.0 mm. aluminium, fractions of 250 to 300 r. One portal is treated each day, rotating until 3,000 r is delivered to each field. The total elapsed time for this series of treatments is from three to five weeks. It is fairly well tolerated by the patient, with only slight nausea and discomfort. Oftentimes a transfusion of whole blood is needed near the completion of the treatment in order to combat the consequent anemia and leukopenia.

External Irradiation by the Radium Element Pack. The radium element pack, which contains 4 grams of the radium salt, is an effective source for the external irradiation of gastric cancer. The filtration is 0.3 mm. of platinum and 1.5 mm. of brass. The radium skin distance generally employed is 15 cm., and the patient is exposed two hours daily until 20 or 30 treatments have been given. The average dose to the skin, then, is 80 to 100 gram-hours (80,000 to 100,000 mg-hr.). The results of this form of therapy, while not satisfactory, have suggested that the harder gamma rays and the increased time factor necessary for these treatments may account for the slightly superior end-results of external radium therapy over high voltage roentgen irradiation.

By the use of isodose curves, which have been prepared by measurements in a water phantom and in a cadaver, the dose actually delivered to the tumor can be accurately estimated. Each patient is measured in the recumbent posture with calipers at the level of the tumor. A representative cross-section of the body at the level of the tumor has been obtained, and projected to the actual size of the individual patient. The location and approximate size of the tumor can be indicated on the section, so that when the isodose is superimposed, the percentage received by the tumor is determined, and the number of threshold erythema doses calculated. As much as 5 threshold erythemas are then delivered to the gastric cancer so treated, and occasionally more.

PREOPERATIVE IRRADIATION OF CANCER OF THE DISTAL HALF OF THE STOMACH

In operable gastric cancer, preoperative external irradiation has not been employed as a routine measure for several reasons. The cancers situated in the distal half of this organ are rarely radiosensitive. These tumors often produce obstruction, thus requiring immediate surgical intervention. There is considerable disability and discomfort from radiation sickness following intensive external irradiation of the epigastrium. There have been 3 instances of severe radionecrosis of the abdominal wall when surgical palliative procedures for inoperable gastric cancer have followed such external irradiation. If preoperative radiation therapy is to be given before laparotomy, the amount must be moderate. We know of 3 instances, however, one in our personal experience, in which gastric cancer said to be inoperable at the time of previous operation was subsequently treated by irradiation and then later was found to be technically dissectable. Such possible conversion of a gastric cancer from an inoperable to an operable state can apply only when the cause of inoperability is not distant or limited metastasis, or involvement of the abdominal esophagus, but rather due to the complication of fixity and adhesions.

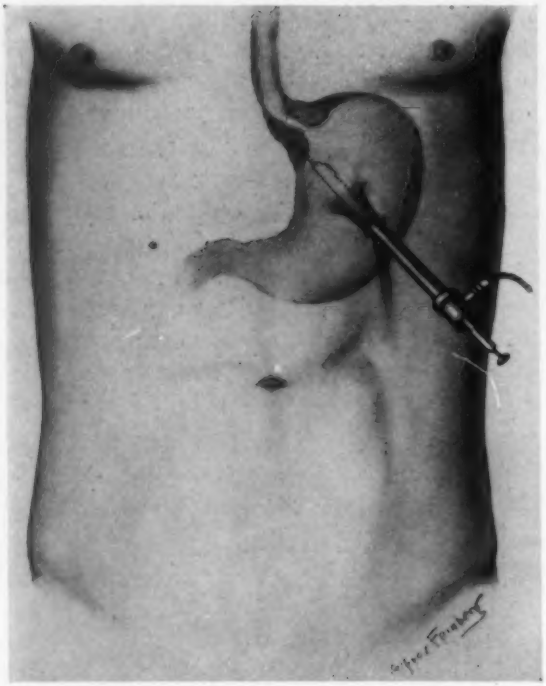

Fig. 1. Interstitial irradiation of carcinoma of the cardia by the insertion of gold radon seeds through a Janeway gastrostomy. The implantation is done under direct visualization by using a bronchoscope, a cystoscope or a child's esophagoscope.

POSTOPERATIVE PROPHYLACTIC RADIATION THERAPY

This is not adopted as a routine procedure, although it may be instituted on the fourteenth day after gastric resection with no fear of delayed wound healing. This treatment is considered possibly useful whenever microscopical examination shows the tumor to be a radiosensitive type.

RADIATION THERAPY OF TUMORS OF THE CARDIA

According to most statistics, only 10 per cent of cancers of the stomach occur in the cardia, but at Memorial Hospital 20 per cent have this location. Most malignant tumors in this site, or in the fundus, are inoperable and are therefore referred to this institution for radiation therapy. Tumors of the fundus, while rare, are the most radiosensitive. They produce metastasis later and less widely. Their radiosensitivity may be explained by their structure. They are vascular and have a papillary, exophytic form, which grows into the lumen instead of infiltrating early.

Interstitial irradiation is attended by less danger in tumors of the cardia because there is less danger of perforation and the neoplasm is farther from other vital organs than it would be in the pyloric end of the stomach. Larger doses may therefore be given in this region, although the mode of exposure is somewhat different. Because the usual symptoms produced by cancer of the cardia are caused by obstruction at the gastric orifice, with consequent irritation of the tumor, bleeding, dehydration and malnutrition, a gastrostomy is performed in order to give symptomatic relief and improve the general health of the patient often before radiation therapy can be instituted. A Janeway gastrostomy is preferred when the wall of the stomach is not too involved, and the anterior wall permits construction of a tube or pedicled flap. The tube is sutured to form a gooseneck with its base at the greater curvature, and the end is sutured to the skin through a small incision under the left costal margin, thus forming a mucosal-lined channel which may remain permanently. The tube

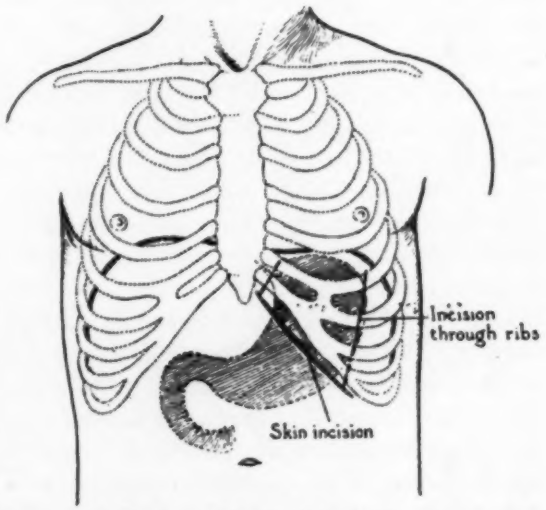

Fig. 2. Diagram of Marwedel's incision below the costal margin and the Baudet and Navarro technique of elevation of the rib flap to expose the cardia.

allows direct visualization of the gastric interior, especially the cardiac portion. The stoma of the gastrostomy is dilated gradually by the use of Hegar cervical dilators. A child's esophagoscope or cystoscope may then be passed into the stomach through the gastrostomy orifice. The empty stomach is then inflated with air, and radon seeds are introduced through long, hollow trocar needles. It is important that the radon seeds are properly spaced in the tumor. No attempt should be made to give the required dose at one time, as the entire tumor cannot be visualized. There are two, three or four implantations, often at weekly intervals. A biopsy may be taken to determine the radiation changes in the tumor.

The surgical exposure of the cardia which permits the employment of interstitial irradiation of cardiac or fundal carcinoma by implantation of radon seeds through the seromuscular coat, is best obtained by the modified Baudet-Navarro technique. The excision extends from the left sternal border in the region of the sixth left costochondral junction parallel to the costal margin, and 1.5 cm. below it to the anterior axillary line. It is carried through the skin, fascia and muscles down to the costal cartilages. The last two cartilages are severed 1½ inches from the sternal margin, and two or three ribs are sectioned at the anterior axillary line. This procedure allows elevation of the rib flap. When it is elevated and turned upward, it affords a clear exposure of the fundus, cardia and abdominal esophagus. The tumor is measured in order to calculate the dose of interstitial irradiation. Gold radon seeds are carefully introduced into the tumor through the gastric wall, holding the hollow needles so that they penetrate the seromuscular layers obliquely before entering the substance of the tumor. It is essential that the needles shall first penetrate the gastric wall for some distance before dipping down into the tumor, because of the danger of leakage. The rib flap may be replaced in position by sutures, usually with kangaroo tendon or it may be removed. The muscles at the costal margin are united with mattress sutures and the skin closed in layers. This wound must withstand a great deal of strain under respiratory movements; postoperative infection has occurred more frequently in our experience in this location than in the usual abdominal incision.

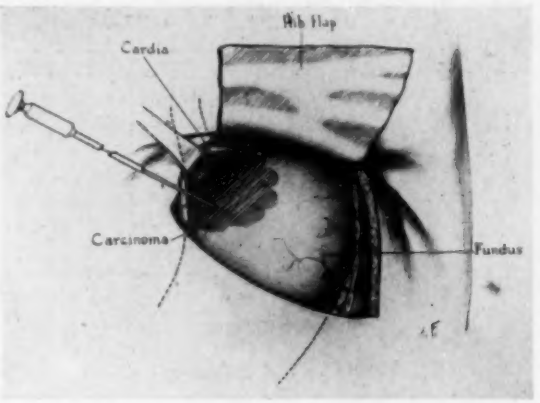

FIG. 3. A drawing to show retraction of the superficial tissues upward, with elevation of the costochondral flap to expose the cardia. Interstitial irradiation of a carcinoma of the stomach is carried out by oblique insertion of gold radon seeds into the tumor.

Complications of Radiation Therapy of Gastric Cancer. Radiation therapy for cancer of the stomach is attended with greater danger of complications than tumors in most other regions. Radiation sickness may be expected in the larger percentage of cases. Occasionally, severe leukopenia follows irradiation of gastric cancer. Hemorrhage frequently complicates unmolested malignant gastric tumors. It has also followed external irradiation of bulky papillary carcinomas which have responded rapidly to irradiation, by necrosis and infarction of the tumor with resultant hemorrhage, because the blood vessels had not become obliterated. In one case, hemorrhage followed two days after the interstitial implantation of four gold radon seeds, giving a total of 6 mc. into a carcinoma of the cardia. Necrosis occurring at an interval after irradiation caused perforation into the colon in one patient who developed a gastrocolic fistula six weeks

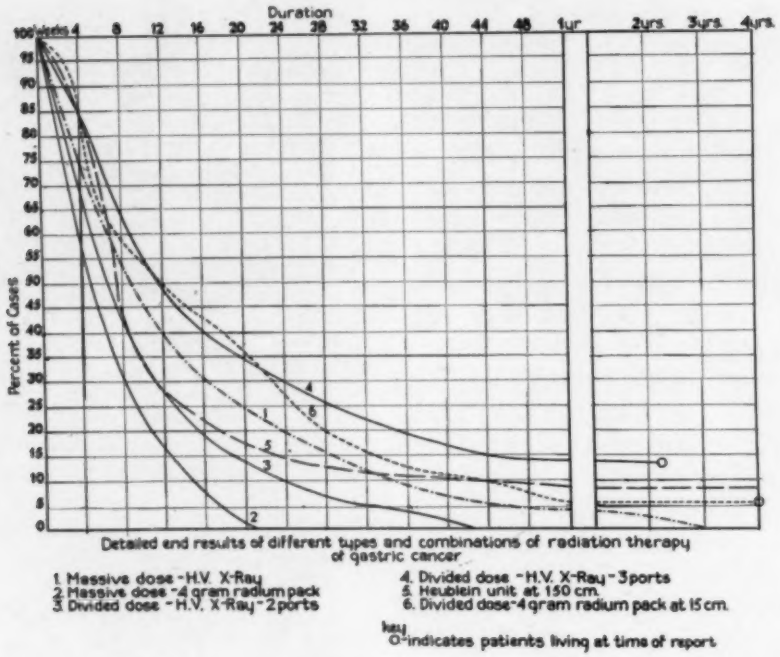
Duration
Weeks 4 8 12 16 20 24 28 32 36 40 44 48 1yr 2yrs 3yrs 4yrs
Percent of Cases
Detailed end results of different types and combinations of radiation therapy of gastric cancer
1. Massive dose - H.V. X-Ray
2. Massive dose - 4 gram radium pack
3. Divided dose - H.V. X-Ray - 2 ports
4. Divided dose - H.V. X-Ray - 3 ports
5. Heublein unit at 150 cm.
6. Divided dose - 4 gram radium pack at 15 cm.
Key
O - indicates patients living at time of report

Chart I. Analysis of end-results following experimental radiation therapy of gastric cancer.

after a large interstitial dose of radon. It represents the only fatality occurring in 268 patients receiving radiation therapy for inoperable gastric cancer.

End-Results of Radiation Therapy of Gastric Cancer

Analysis of the end-results of different types and combinations of radiation therapy

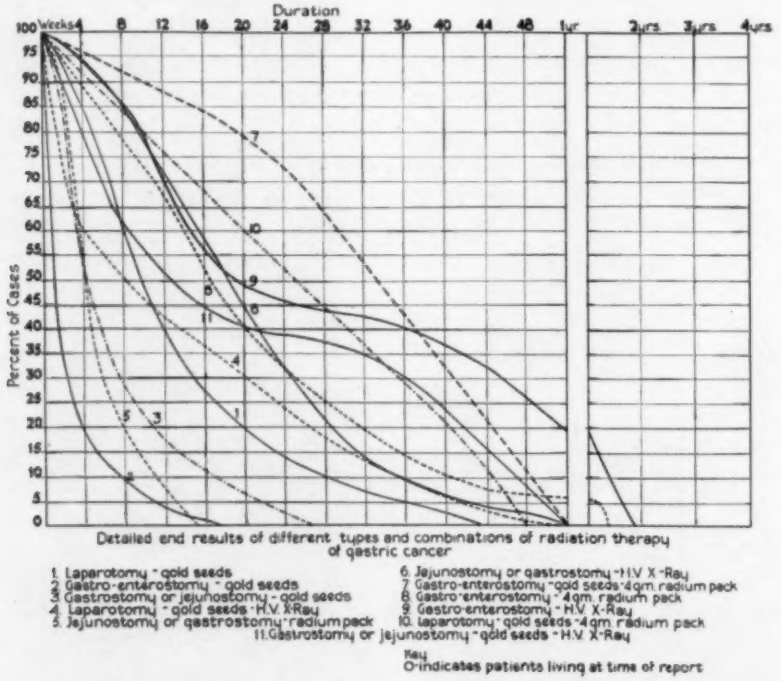
Duration
Weeks 4 8 12 16 20 24 28 32 36 40 44 48 1yr 2yrs 3yrs 4yrs
Percent of Cases
Detailed end results of different types and combinations of radiation therapy of gastric cancer
1. Laparotomy - gold seeds
2. Gastro-enterostomy - gold seeds
3. Gastrostomy or jejunostomy - gold seeds
4. Laparotomy - gold seeds - H.V. X-Ray
5. Jejunostomy or gastrostomy - radium pack
6. Jejunostomy or gastrostomy - H.V. X-Ray
7. Gastro-enterostomy - gold seeds - 4 gm. radium pack
8. Gastro-enterostomy - 4 gm. radium pack
9. Gastro-enterostomy - H.V. X-Ray
10. Laparotomy - gold seeds - 4 gm. radium pack
11. Gastrostomy or jejunostomy - gold seeds - H.V. X-Ray
Key
O - indicates patients living at time of report

Chart II. Analysis of end-results following experimental therapy of gastric cancer.

of gastric cancer (see Charts I and II). Gastric cancers are either fairly radiosensitive (minority) or quite radioresistant (majority). Since this is true, the various modalities of irradiation do not influence so greatly the initial response to treatment nor the prolongation of life. In fact, if a gastric cancer will regress temporarily following such treatment, our experience has indicated that improvement in radiation technique or multiples of such doses will within certain limits not greatly enhance the palliation obtained. The life curve of those patients treated by massive dose roentgen radiation (Chart I, curve 1) reveals a slightly higher proportionate survival period than does the curve of patients treated by the modern fractionated dose principle when only two portals are used (Chart I, curve 3). For example, at the end of twenty-four weeks following treatment 10 per cent of patients treated by the latter method were living, whereas 20 per cent of the former were still alive. Twenty-seven per cent of the patients treated by the fractionated dose method employing the 4-gram radium pack at 15 cm. distance over two skin portals were alive at the end of the same period (Chart I, curve 6). The addition of a third or fourth left upper lateral field is a useful adjunct for roentgen irradiation of gastric cancer. These additional portals were added to the treatment of 13 patients who survived the roentgen treatment to two portals and were considered strong enough to continue. When this third portal was added, a definite increase in life expectancy was observed, as 27 per cent of these patients were living at the end of six months (Chart I, curve 4).

Table II

Divided doses of roentgen rays (2 portals)	End-results at 8 months— 5% living
Divided doses of roentgen rays (3 portals)	End-results at 8 months—22% living
Divided doses by radium pack	End-results at 8 months—16% living
Massive single doses by roentgen rays	End-results at 8 months—11% living

Chart II illustrates the hazards of interstitial irradiation performed at the time of gastroenterostomy (curve 2). The intense focal radium reaction in the stomach so closely adjacent to the anastomosis may prevent satisfactory wound healing and is a perilous procedure. Gastroenterostomy alone for obstructing cancer of the distal third of the stomach affords only short palliation. The average length of life of all patients following gastroenterostomy for cancer is only six months (collected figures from all world clinics). It would appear from an analysis of curves 8 and 9, Chart II, that the addition of external irradiation to gastroenterostomy improves these average figures.

Table III

	Duration of Life without Irradiation			With Irradiation		
	6 mo.	8 mo.	1 yr.	6 mo.	8 mo.	1 yr.
Laparotomy	12%	0%	0%	36%	28%	20%
Gastroenterostomy	22%	15%	4%	53%	31%	17%
Gastrostomy and jejunostomy	0%	0%	0%	15%	8%	4%
Gastrectomy	75%	72%	63%	93%	90%	86%

Does the addition of radiation therapy to surgical procedures prolong life? (see Charts III and IV). A study of these charts confirms the previous statement as to the palliative value of radiation therapy as a supplement to non-curative surgical meas-

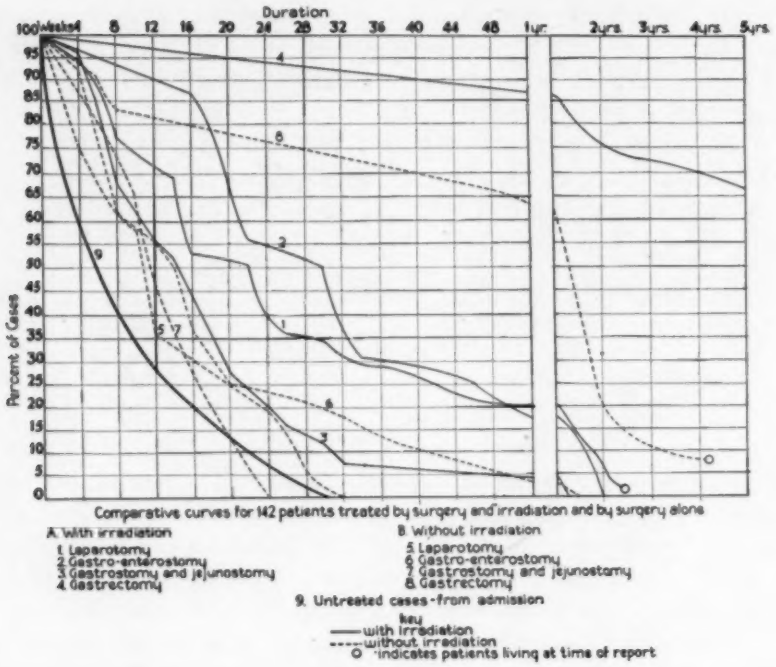

Chart III. Analysis of end-results following experimental therapy of gastric cancer.

ures. Curve 9 on Chart III shows the life expectancy of patients with gastric cancer who receive no treatment either surgical or radiological; the curve starts from the time of application to the hospital as do the companion curves. It offers an interesting basis for estimating the palliative values of combined surgical and radiation treatment. The duration of life of the untreated patient usually averages less than four months from date of application to the hospital; these figures from Memorial Hospital are practically identical with those of Lord Moynihan and of Livingston (New York City Cancer Institute).

Gastroenterostomy for stenosing cancers of the distal third of the stomach enables the patient to live longer and suffer more.

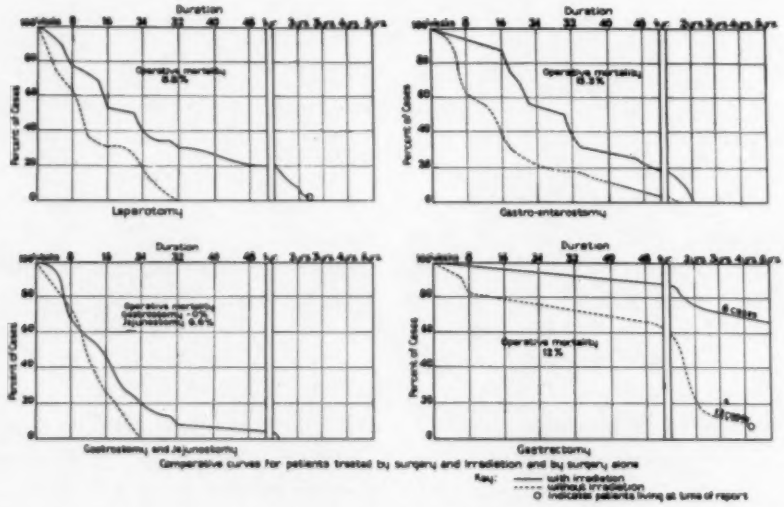

Chart IV. Analysis of end-results following experimental therapy of gastric cancer.

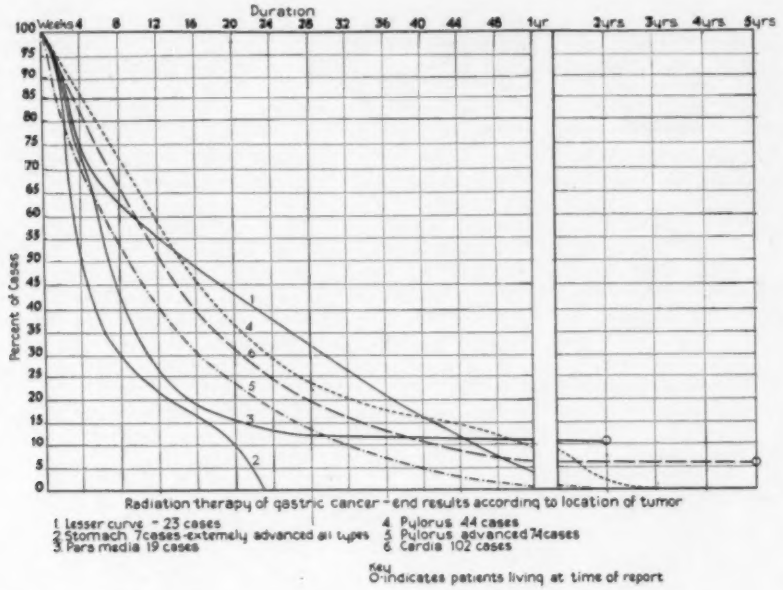
Duration
Weeks 4 8 12 16 20 24 28 32 36 40 44 48 1yr 2yrs 3yrs 4yrs 5yrs
Percent of Cases
Radiation therapy of gastric cancer - end results according to location of tumor
1. Lesser curve - 23 cases
2. Stomach 7 cases-extremely advanced all types
3. Pars media 19 cases
4. Pylorus 44 cases
5. Pylorus advanced 74 cases
6. Cardia 102 cases
Key
O-indicates patients living at time of report

CHART V. Analysis of end-results following experimental therapy of gastric cancer.

The degree of additional palliation afforded by supplementary irradiation should not be measured entirely by the prolongation of life (which does obtain) but also by improvement in the sense of well-being which some of these patients experience. The curtailment of life in some of these patients has been due to the continued growth of metastatic carcinoma in the liver or abdominal lymph nodes at a time when the

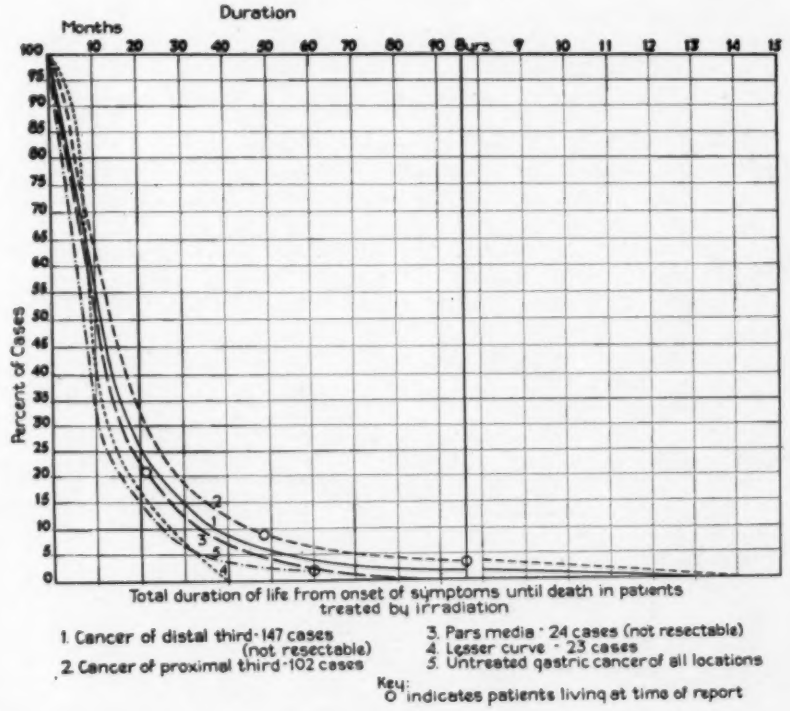
Duration
Months
Yrs
Percent of Cases
Total duration of life from onset of symptoms until death in patients treated by irradiation
1. Cancer of distal third - 147 cases (not resectable)
2. Cancer of proximal third - 102 cases
3. Pars media - 24 cases (not resectable)
4. Lesser curve - 23 cases
5. Untreated gastric cancer of all locations
Key:
O indicates patients living at time of report

CHART VI. Analysis of end-results following experimental therapy of gastric cancer.

Table IV

	Living at 6 mo.		Living at 6 mo.
Laparotomy + gold radon seeds	13%	Same + external irradiation	52%
Gastroenterostomy + gold radon seeds	0%	Same + external irradiation	72%
Gastrostomy and jejunostomy + gold radon seeds	2%	Same + external irradiation	39%

primary cancer in the stomach has been well controlled.

Interstitial Irradiation of Gastric Cancer. The addition of interstitial irradiation seems to offer slight advantage unless external irradiation is also employed. The introduction of gold radon seeds is only practical when the cancer is small enough to permit of accurate implantation, e.g., in the cardia. In other portions of the stomach the cancer would be resected if technically possible and the cause of unresectability is the same as the reason for failure to employ interstitial irradiation successfully, namely an extensive diffuse carcinoma with distant or visceral metastasis (see Chart II).

End-Results According to Location of Tumor. A separate attempt was made to classify cancers of the stomach into their regional distribution in order to see if any real difference in radiosensitivity existed (Chart v). There seems to be little evidence of such differential radiosensitivity with the possible exception of cancers involving the lesser curvature; although the initial response of cancers in this location is the best, yet the rate of survival for periods over one year is less than that obtained for cancers of the pars media, fundus and cardia.

Table V

Region	No. of Cases	Survivals at			
		6 mo.	8 mo.	10 mo.	1 yr.
Pylorus	44	29%	18%	15%	9%
Pylorus advanced	73	16%	8%	4%	1%
Lesser curvature	23	35%	24%	14%	4%
Entire stomach	7	0%	0%	0%	0%
Pars media	19	13%	13%	13%	13%
Cardia	102	23%	15%	10%	7%

Summary of End-Results. Table VI is planned to summarize the degree of palliation obtained by radiation therapy of gastric cancer.

Living Patients (beyond ordinary period of palliation).

a. Surgery + radiation therapy = 5. = Duration—2, 5, 5, 6 and 10 years.

Table VI

Region	No. of Cases	Worth While Palliation	Excellent Palliation
Pylorus	44	27%	7%
Distal half	73	17%	3%
Lesser curvature	23	28%	9%
Pars media	19	16%	19%
Entire stomach	7	0%	0%
Cardia	102	20%	5%
	268 cases	20%	6%

b. Radiation therapy alone = 4. = Duration—2, 2, 4 and 9 years.

CONCLUSIONS

1. The majority of gastric cancers are extremely radioresistant.

2. Gastric cancer is usually in such an advanced stage when seen by the radiotherapeutist that treatment in any form can be considered only palliative.

3. Although the present methods of radiation therapy have prolonged the life expectancy of the average patient with inoperable gastric cancer and made some patients more comfortable, they offer little of curative value.

4. One out of every five patients treated receives some worth while palliation. In one patient out of twenty the results of treatment are remarkable and definitely beneficial.

5. The initial response of cancers of the lesser curvature to irradiation is the best of any of the regional distributions, yet the rate of survival for periods over one year is less than that obtained for cancers of the pars media, fundus and cardia.

6. The addition of radiation therapy to surgical procedures (both curative and palliative) does prolong the life expectancy of the patient with gastric cancer.

7. The utilization of all the factors which influence depth dosage, the prolongation of the total period of treatment with daily fractionated doses and the use of multiple portals for external irradiation may result in better palliation in the future.

REFERENCES

1. Evans, W. A., and Leucutia, T. Results of deep roentgen treatment of gastrointestinal malignancies. Am. J. Roentgenol. & Rad. Therapy, 1923, *10*, 793–801.
2. Gosset, A., Monod, O., and Regaud, C. Traitement des cancers gastriques inextirpables par le radium à distance. *Bull. Acad. de méd.*, 1933, *110*, 379–394.
3. Despeignes, V. Observations on a case of cancer of the stomach treated by roentgen rays. *Lyon méd.*, 1896, *82*, 428.
4. Holfelder, H. Wass kann man heute von der Röntgentherapie der sogenannten inoperablen Tumoren erwarten? *Strahlentherapie*, 1929, *33*, 131–138.
5. Holfelder, H. Methodische Fortschritte der Röntgentherapie der Krebse des Verdauungskanals. *Strahlentherapie*, 1931, *42*, 497–503.
6. Janeway, H. H. Gastroscopy. *J. Am. M. Ass.*, 1913, *61*, 1339.
7. Janeway, H. H. Action of radium in cancer. *Surg., Gynec. & Obst.*, 1918, *26*, 233. Cited by Ewing, J. Early experiences in radiation therapy. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 153–163.
8. Janeway, H. H., and Green, N. W. Esophagoscopy and gastroscopy. *Surg., Gynec. & Obst.*, 1911, *13*, 245–253.
9. Levin, I. Intraperitoneal insertion of buried capillary glass tubes of radium emanation. *J. Am. M. Ass.*, 1922, *79*, 2074–2076.
10. Pack, G. T., Scharnagel, I. M., Quimby, E. H., and Loizeaux, M. C. Palliative irradiation of gastric cancer. *Arch. Surg.*, 1935, *31*, 851–896.
11. Schmidt, W. Die Ergebnisse der Röntgentherapie bösartiger Geschwülste an der Chirurgischen Universitätsklinik zu Göttingen in den Jahren 1919–1927. *Strahlentherapie*, 1928, *30*, 197–238.
12. Scholz, T. Application of roentgen radiation to barium-filled stomach. *Radiology*, 1932, *18*, 269–276.
13. Werner, R. Tumoren des Magendarmtraktes. In: Gauss, C. J. Lehrbuch der Strahlentherapie. Urban & Schwarzenberg, Berlin, 1927, *2*, 228.
14. Wickham, L.-F., and Degrais, P. Radium and Cancer. Paul B. Hoeber, Inc., New York, 1914.

THE TREATMENT OF ACUTE PNEUMONIAS WITH ROENTGEN RAYS*

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DURING the past decade so much has been written on the use of roentgen rays in the treatment of acute infectious and inflammatory conditions, especially furuncles, carbuncles, and erysipelas, that it is surprising to find so little mention made of roentgen therapy of acute pneumonias. There are many references to the use of roentgen therapy for chronic or unresolved pneumonia, but when I began treating the acute cases five years ago, I found no reference giving any specific data as to dosage, results to be expected, or influence, if any, on mortality. The only definite information I had at that time was from the late Samuel Stern, who, a number of years before, had told me that roentgen therapy was being used in treating acute lobar pneumonia at some of the European clinics, and that many of the cases treated developed a crisis within twenty-four hours afterward. Recently, however, two articles published in 1924[1,2] and one published in 1937[3] have come to my attention. They are all in German journals.

I had been using roentgen irradiation with much success in the treatment of many acute localized infectious conditions for some time, so in January, 1933, my staff at the King's Daughters' Clinic agreed to let me try roentgen therapy in alternate cases of acute pneumonia. We continued to use all other methods of treatment the same as before so that the only difference would be the influence of the irradiation. We were using no antipneumococcic serum. It was very soon noted that the patients receiving roentgen therapy not only frequently developed a prompt crisis, but nearly all of them were relieved of their distress and discomfort within a few hours after the roentgen treatment, and we were soon convinced that it was too valuable a therapeutic agent not to be used in all cases of pneumonia. Since then we have used it routinely.

At the start, because we were using serum in none of the cases, we did not type sputums for pneumococcus. However, since last year, when my preliminary report[4] was criticized because I had not differentiated the types of organisms found, we have done so, and of 49 cases from whom sputum has been obtained, 11 were Type I; 5 were Type II; 6 were Type III; and 19 were in the remaining types. Eight patients showed mixed infection with organisms other than the pneumococcus.

Rufus Cole[5] stated that only cases in which the pneumococcus was found should be considered as acute lobar pneumonia. However, we see many cases that clinically are lobar pneumonia and the diagnosis confirmed by history, physical signs, roentgen examination, and subsequent course of their illness, but in whose sputum no pneumococci can be found. We are more inclined to agree with B. M. Fried[6] in believing that pneumonia may be an allergic reaction by the lungs to a previous sensitization. If so, this may account for the good results following irradiation, as there seems to be something common, not only to all pneumonias, but to many other localized infectious conditions that is favorably influenced by roentgen treatment.

Patients of all ages, from two to seventy years,† have been treated, and to the date of this writing (July, 1937) I have used roentgen therapy in 105 cases of lobar pneumonia and in 30 cases of bronchopneumonia. Five of the cases of lobar pneumonia and 4 of the cases of bronchopneu-

† Since reading this paper I have treated a male patient, aged seventy-six, having a Type III pneumonia involving the lower lobes of both lungs complicating a fractured femur. He recovered following roentgen therapy.

* From the Radiological Department, King's Daughters' Clinic, Temple, Texas. Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

monia died, giving a mortality of less than 5 per cent for the former, and 13 per cent for the latter. The records of our hospital show a mortality of 29 per cent for lobar pneumonia and 30 per cent for bronchopneumonia prior to the use of roentgen therapy.

Specific immune serum has been used in only 3 cases. These were in Type 1 pneumococcus infections. The serum was given before the roentgen treatment. Two of these 3 cases died. The other deaths in lobar pneumonia cases have occurred in 2 untyped cases, and 1 with an undifferentiated type pneumococcus. This last patient was known to have had tuberculosis and bronchiectasis before he became ill with pneumonia. He had also had pneumonia some years before this fatal attack. He developed a lung abscess and died four months after the onset of pneumonia and two months after leaving the hospital.

Other complications have been observed in 7 patients who developed empyema and required surgical drainage; and 2 cases with empyema that resolved and absorbed without surgical intervention.

The technique I originally used gave good results and it has remained much the same as when we started. We give 250 to 350 roentgens, using 135 kv., 3 mm. aluminum filter (on our equipment this gives radiation of 0.3 Å. effective). We use a 40 cm. skin-target distance. The filter is heavier and the distance is greater than usually used in treating acute infections, but it tends to more homogeneously irradiate a large mass of solid tissue such as is present in a pneumonic lung. Also, the total dosage on the skin is larger than is generally used in acute conditions, but the depth dose is not large, and we think that our results warrant continuation of our present technique. As soon as the diagnosis is made from history, physical and roentgen examination, and the blood count (this usually takes about fifteen minutes), treatment is given anteriorly or posteriorly over an area a little larger than the involved portion of the lung. A definite leukopenia such as is found in some postinfluenzal pneumonisa is the only contraindication to roentgen treatment we have observed. We do not wait for sputum typing, but give a roentgen treatment immediately. Sputums are typed though as soon afterward as they can be obtained.

If the temperature has not returned to normal or below within thirty-six hours following the first roentgen treatment, a second treatment of 200 r is given over the opposite skin area. When roentgen treatment is given before consolidation is complete it may spread, but the patient shows the usual clinical improvement, and temperature, pulse, respiration and leukocyte count return to normal. This is similar to the often made observation that the patient recovers clinically days or even a week or two before the pulmonary consolidation resolves. A few cases with mixed infection have required a third or fourth treatment, using, of course, successively smaller doses so as to avoid skin reaction. Mixed infection cases are more apt to recover by lysis after an initial drop from the high temperature to a moderate elevation above the normal.

Bronchopneumonia seems more variable in its response to radiation therapy. This may be because there are so many stages of the disease present at one time. McIntire and Smith[7] have recently reported, however, that if bronchopneumonia is first stabilized over a period of forty-eight hours with diathermy, it will then respond as well as does lobar pneumonia. I have not as yet had an opportunity to check their observation. I do believe, however, that roentgen therapy does materially reduce the mortality from bronchopneumonia.

Our patients have been treated in all stages of the disease, from the first to, in one case, the eleventh day. Most of the patients show relief of distress and general symptomatic improvement within a few hours, and more than one-third of them have shown a drop in temperature to normal or below within thirty-six hours after the treatment. A number of patients' temperatures have returned to normal in less then twelve hours after treatment.

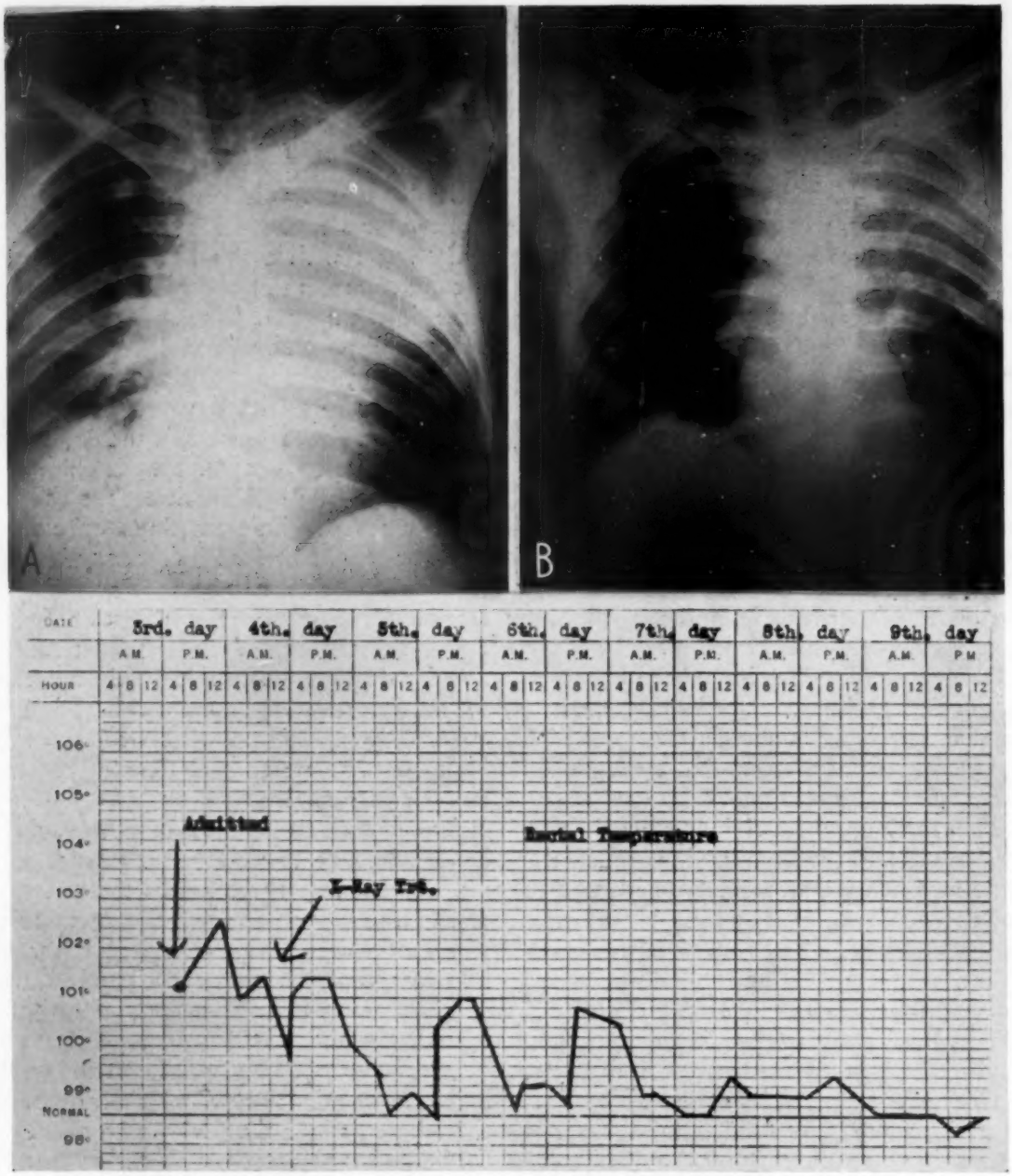

FIG. 1, *A*, *B* and *C*. Case 1.

The following case histories of pneumonia patients treated with roentgen rays are presented to show the general reactions. They are selected from the series because they show the results we expect to get.

CASE REPORTS

CASE 1. White male, aged forty-two. This case is of interest, because the patient, his mother and his daughter were in the hospital ill with pneumonia at the same time. He was admitted to the hospital on the third day of his illness which started with a chill, pain in the left upper chest, high fever, and blood-tinged sputum. On admission to the hospital the patient had a temperature of 101.2°F., pulse 112, respiration 30. Leukocyte count 24,600, with 94 per cent polymorphonuclears, nuclear index 3.5. Sputum showed general mixed infection, few pneumococci not Types I, II or III. Roentgen examination of the chest (Fig. 1*A*) showed consolidation of the left upper lobe and be-

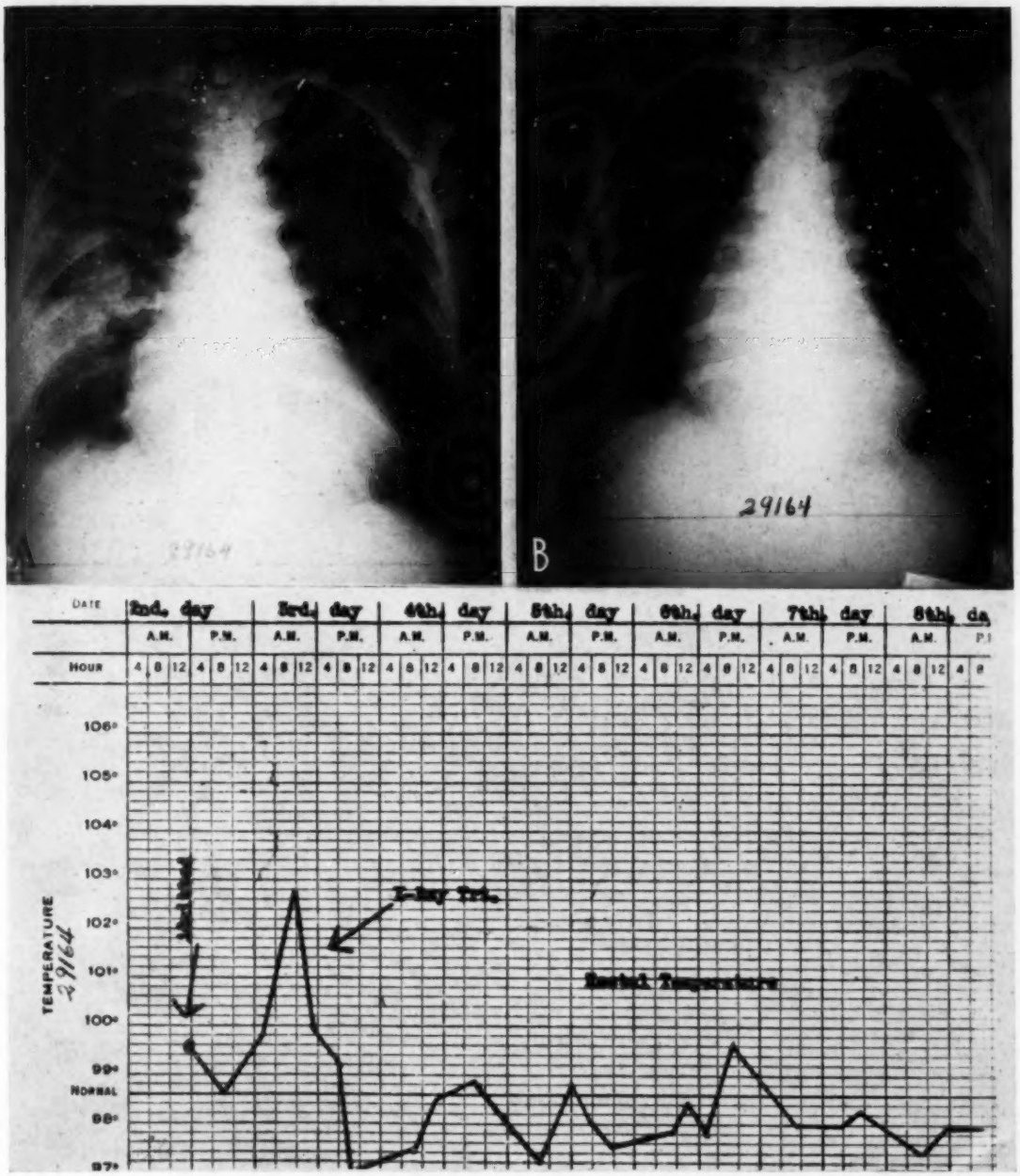

Fig. 2, *A*, *B* and *C*. Case II.

ginning in the right middle lobe. On the morning after his admission, roentgen treatment was given and the following day his temperature dropped to normal. During the next two days it rose to a little more than 100°F., after which it remained normal. A roentgenogram six days later (Fig. 1*B*) showed more than 50 per cent resolution. Figure 1*C* shows patient's temperature curve during his stay in the hospital.

Case II. White female, aged sixty-eight. Patient had a severe cold for nearly two weeks. Forty-eight hours before admission was awakened with a chill, coughed up blood-tinged sputum. Temperature 105°F., pulse 100, respiration 28. Leukocyte count 26,300, with 90 per cent polymorphonuclears, nuclear index 2. Sputum showed Type III pneumococci. On admission her temperature was 99.8°F., but this was due to an antipyretic which was given before she was sent to the hospital. Temperature rose to 103°F. during the following twelve

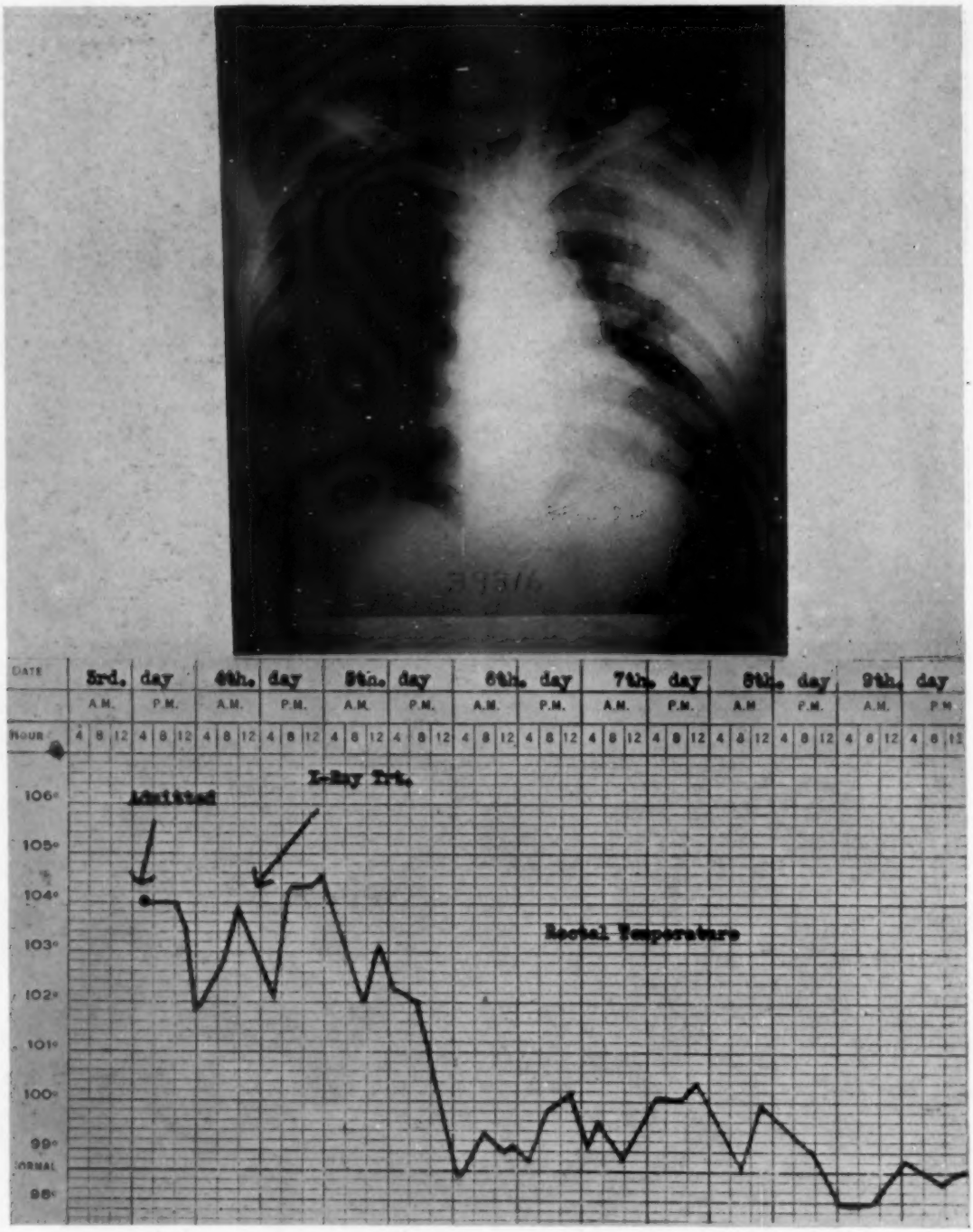

Fig. 3, *A* and *B*. Case III.

hours. Roentgen treatment was given on the morning after admission. Six hours later the temperature dropped to 97°F., and varied from 97° to 99°F. during the remaining time she was in the hospital. The day after her temperature returned to normal, pneumococci from the patient's sputum were mixed with her serum and these showed some swelling of their capsules. Illustrations show roentgenograms taken on day of admission (Fig. 2*A*), and four days later (Fig. 2*B*), and temperature curve (Fig. 2*C*) during her stay in the hospital.

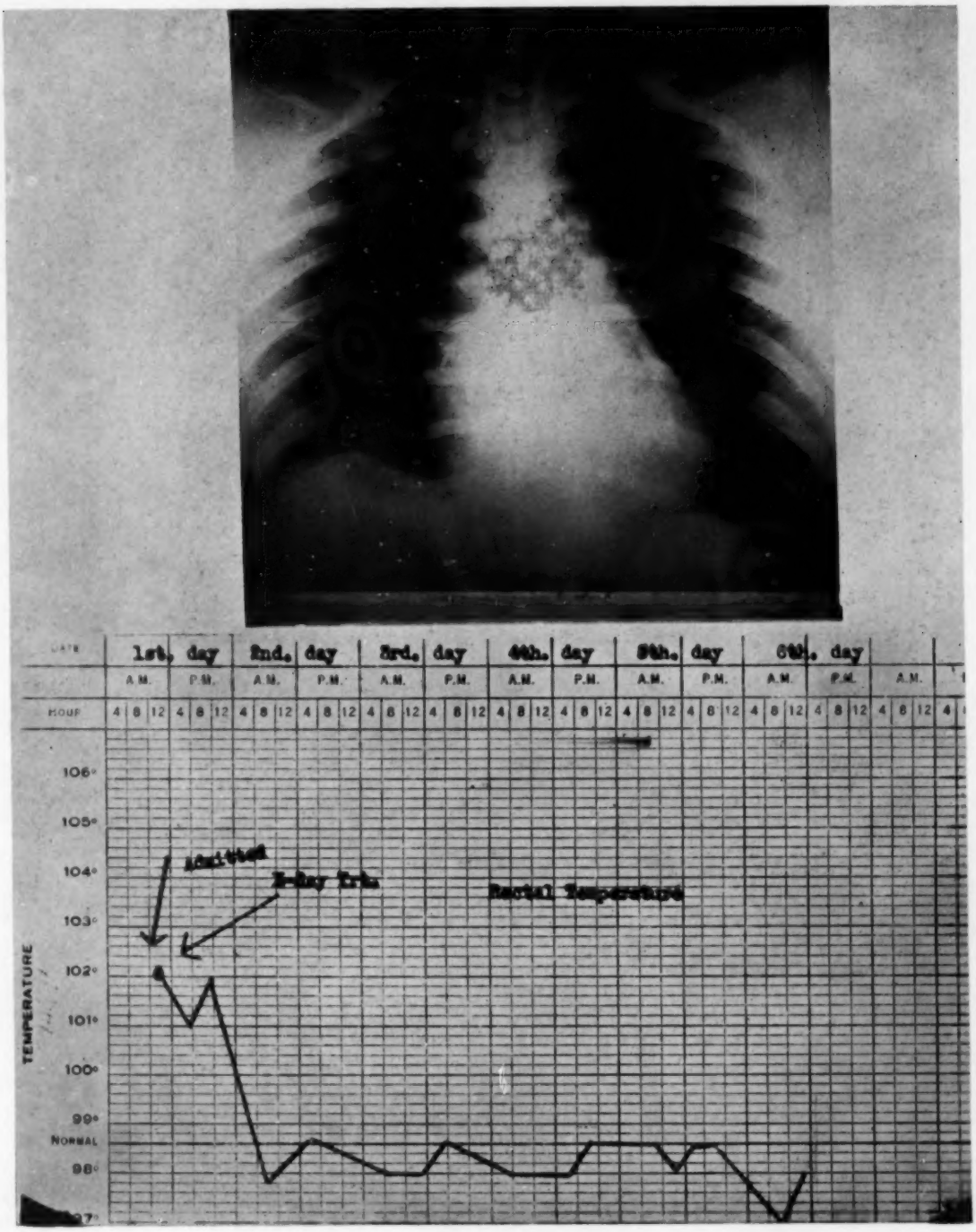

FIG. 4, *A* and *B*. Case IV.

CASE III. White male, aged thirty-two. Patient was admitted to the hospital forty-eight hours after onset of illness which began with pain in the left infraclavicular region, cough and fever. On admission the patient had a temperature of 104°F., pulse 120, respiration 32. Leukocyte count 20,800, with 70 per cent polymorphonuclears, nuclear index 6. Sputum showed Type II pneumococci. Roentgen treatment was given on the morning after admission and thirty-six hours later patient's temperature had dropped to 98°F., after which time it

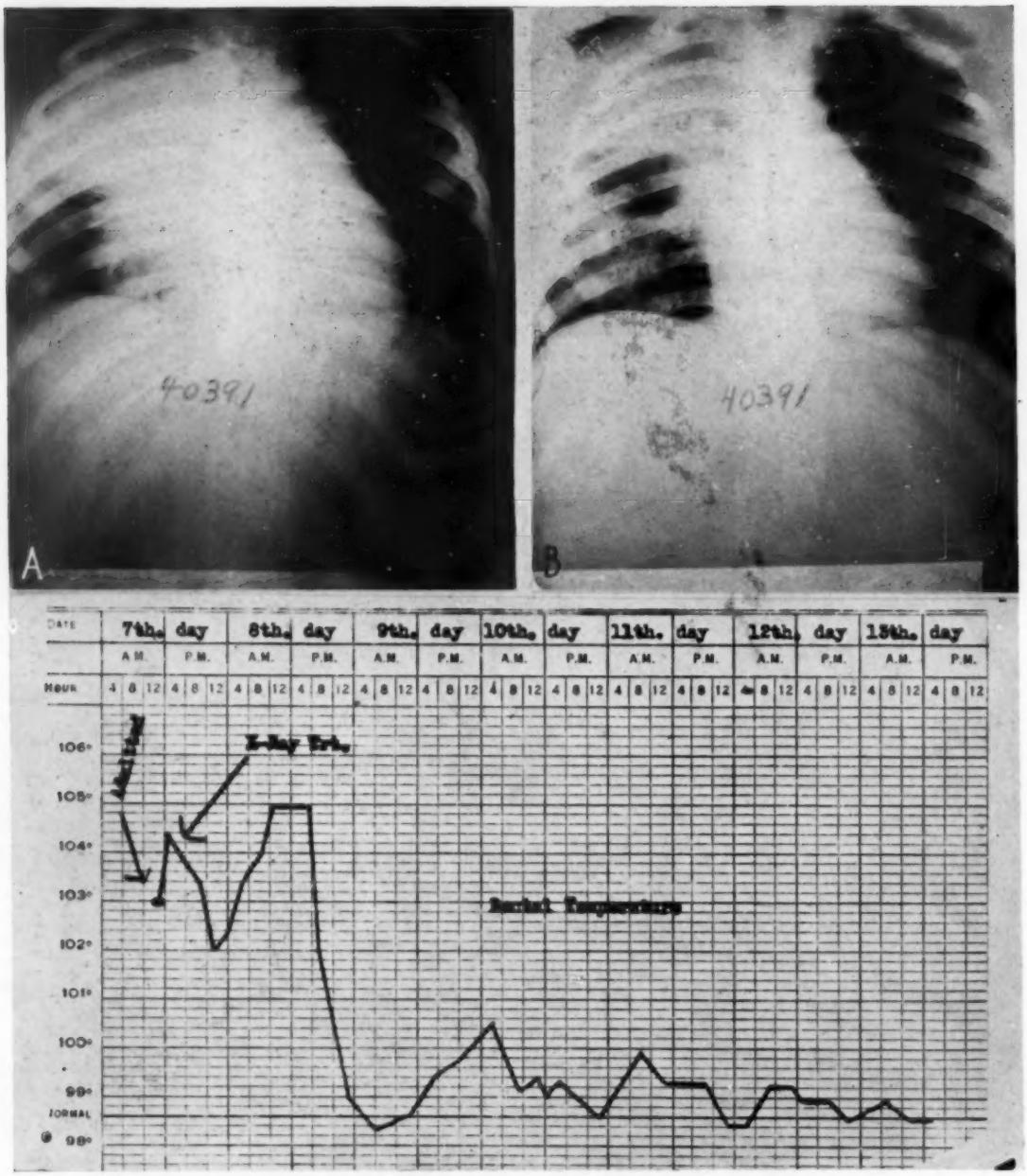

Fig. 5, *A*, *B* and *C*. Case v.

showed minor variations up to 100°F. during the rest of the stay in the hospital. Illustrations show roentgenogram on admission (Fig. 3*A*) and temperature curve (Fig. 3*B*) throughout the patient's stay in the hospital. No roentgenogram was obtained during convalescence.

Case iv. White female, aged forty-four. Patient had a cold for about two weeks. On morning of the day she was admitted to the hospital, she had a chill, fever, pain in the right upper chest. Her temperature on admission was 102°F., pulse 104, respiration 28. Leukocyte count was 19,200, with 74 per cent polymorphonuclears, nuclear index 4.4. Sputum contained Type iii pneumococci. Roentgen examination showed incomplete consolidation of the right upper and left lower lobes. Roentgen treatment was given on admission. Sixteen hours later patient's temperature dropped to

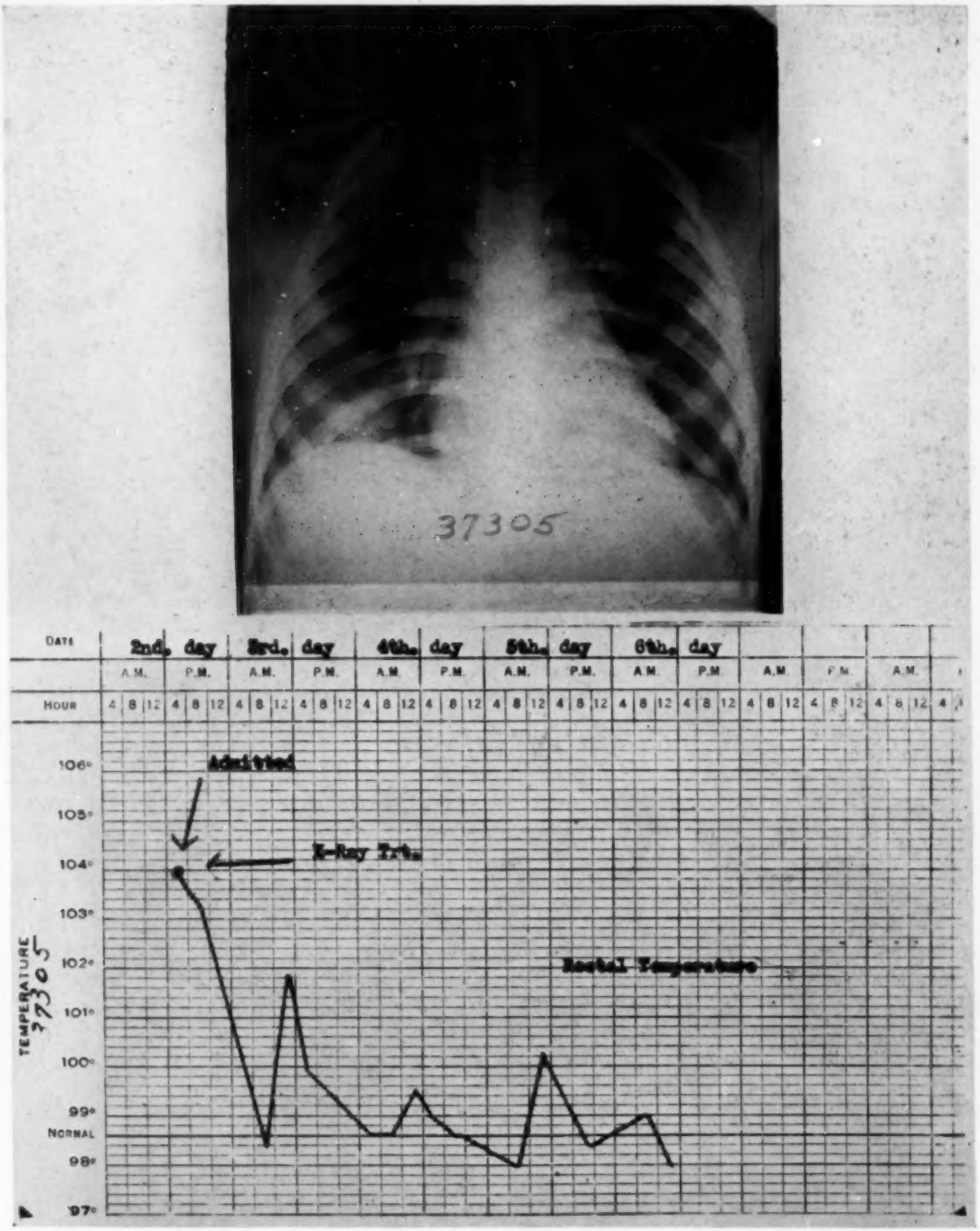

Fig. 6, *A* and *B*. Case vi.

98°F., and varied little from the normal during the rest of the stay in the hospital. Illustrations show roentgenogram on admission (Fig. 4*A*) with temperature curve (Fig. 4*B*) throughout the patient's stay in the hospital. No roentgenogram was obtained during convalescence.

Case v. White male, aged ten. Illness began one week before admission to the hospital with chill, fever, and pain in the right chest. On admission to the hospital his temperature was 103°F., pulse 136, respiration 48. Leukocyte count was 17,800, with 80 per cent polymorpho-

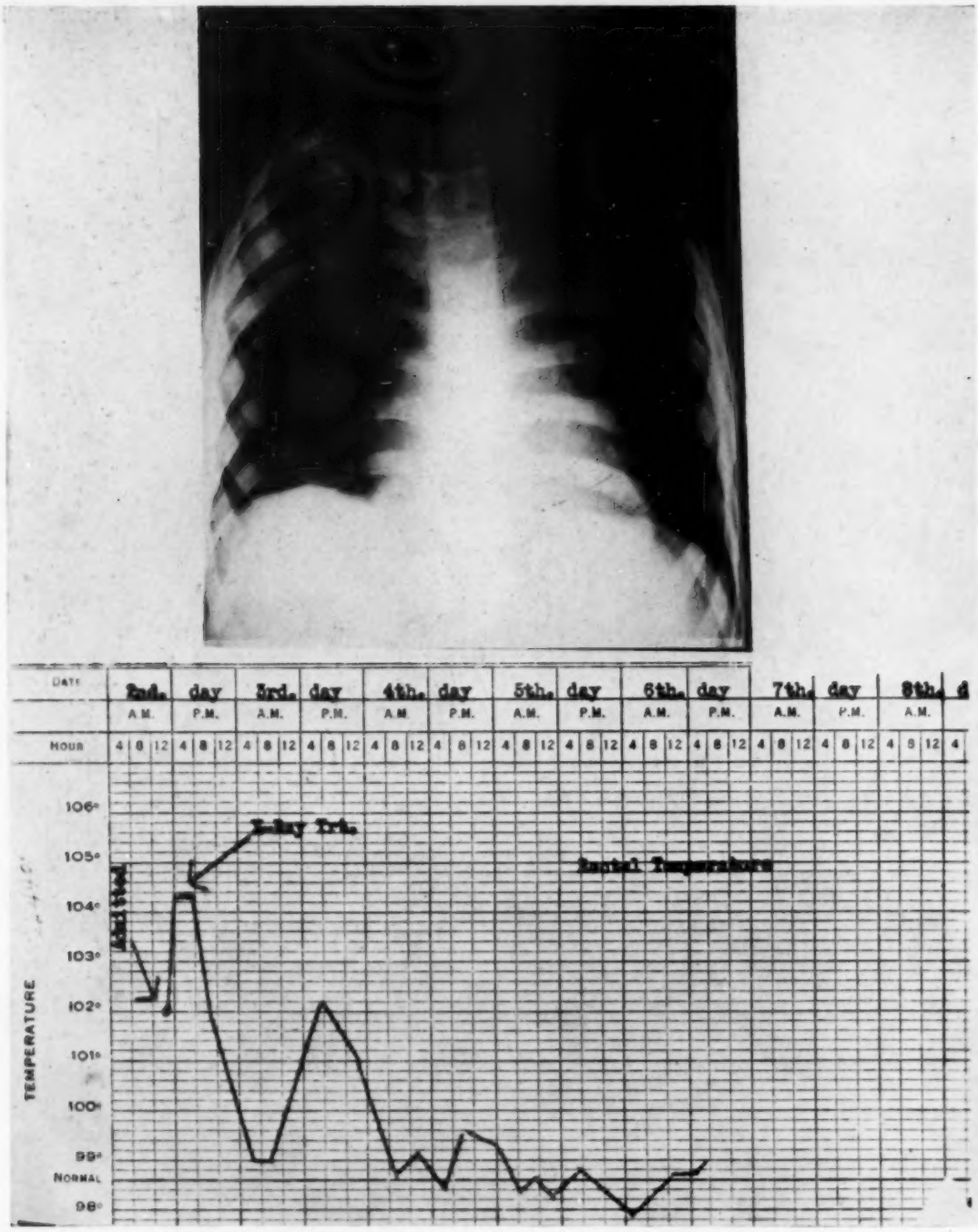

Fig. 7, *A* and *B*. Case vii.

nuclears, and nuclear index 2. Sputum contained Type I pneumococci. Roentgen examination of the chest (Fig. 5*A*) showed complete consolidation of the right upper lobe. Roentgen treatment was given and thirty-six hours later the patient's temperature was normal, and varied little from the normal throughout his convalescence. Six days later roentgen examination of the chest showed the lung to be almost clear (Fig. 5*B*). Figure 5*C* shows patient's temperature curve during his stay in the hospital.

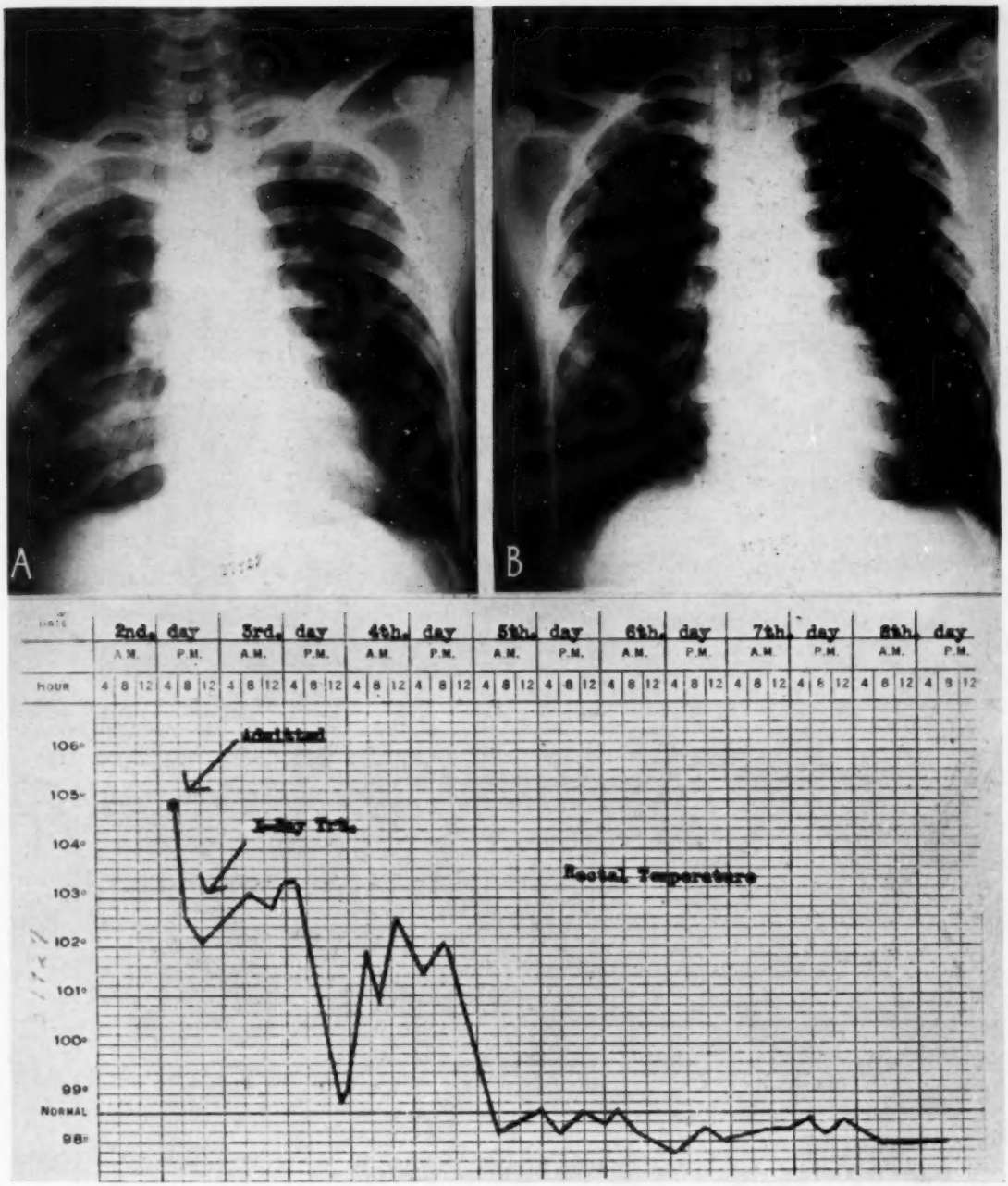

Fig. 8, *A*, *B* and *C*. Case VIII.

Case VI. White male, aged eight. Patient had a cold for about a week, which was not severe. While in school day before admission to the hospital he had a chill followed by fever, and pain in the right chest. On admission to the hospital twenty-four hours after onset the patient had a temperature of 103.6°F., pulse 106, respiration 30. Leukocyte count was 24,500, with 84 per cent polymorphonuclears, nuclear index 4.2. Sputum showed general mixed infection with pneumococci not Type I, II or III. Roentgen examination of the chest (Fig. 6*A*) showed incomplete consolidation of the right lower lobe and roentgen treatment was given. Twelve hours later his temperature was normal. During that day his temperature rose to 102°F. and returned to normal the following morning, after which time it showed

minor fluctuations during the rest of the stay in the hospital. Roentgenogram during convalescence was not obtained. Figure 6*B* shows patient's temperature curve during his stay in the hospital.

Case vii. White male, aged nine. On the day before admission patient came home from school with a chill followed by fever, cough, pain in the chest, and expectoration of blood-tinged sputum. On admission to the hospital he had a leukocyte count of 34,000, with 90 per cent polymorphonuclears, nuclear index 5.9. Roentgen examination (Fig. 7*A*) showed consolidation of the right upper lobe. On admission he had a temperature of 104°F., pulse 146, respiration 40. Sputum showed Type II pneumococcus. Roentgen treatment was given on admission, and sixteen hours later the temperature was normal. This was followed by a rise to 102°F. the following day. His temperature returned to normal and varied little from the normal during the rest of the stay in the hospital. No roentgenogram was obtained during convalescence. Figure 7*B* shows patient's temperature curve throughout his stay in the hospital.

Case viii. White male, aged seventeen. Patient was taken ill about thirty hours before admission to the hospital with pain in the right chest, cough, and fever. Twenty-four hours after onset he raised blood-tinged sputum. On admission his temperature was 104.4°F., pulse 124, respiration 28. Leukocyte count was 23,700, with 93 per cent polymorphonuclears, nuclear index 1.2. Roentgen examination of the chest (Fig. 8*A*) showed practically complete consolidation of the right lower lobe. Sputum showed pneumococci not Types I, II or III. Roentgen treatment was given two hours after admission. His temperature dropped to 98.8°F. twenty-four hours later, but that day rose to 102°F. Ninety-six hours after onset temperature was normal and remained so during the rest of the stay in the hospital. Three days after admission roentgen examination (Fig. 8*B*) showed almost complete resolution. Leukocyte count on the fifth day was 7,000 with 62 per cent polymorphonuclears. Figure 8*C* shows patient's temperature curve throughout his stay in the hospital.

Lest it be assumed that roentgen therapy makes the treatment of these cases too easy I would stress the fact that pneumonia patients are sick patients, and must be treated as such. They must be watched carefully and such symptomatic treatment as is indicated used. We use digitalis only when there is definite cardiac decompensation. We use oxygen when there is cyanosis or when the respiratory rate is high enough to be exhausting to the patient. Metrazol is used as a respiratory and peripheral circulatory stimulant. Morphine or dilaudid as indicated is given for pain. Very high fever is usually controlled by ice caps and cold colon flushes. We do not like to use antipyretic drugs.

SUMMARY

In addition to the usual therapeutic routine, 105 cases of lobar pneumonia have been given roentgen treatment. Of these only five died. Thirty cases of bronchopneumonia have been given roentgen treatment and of these four died. Even if the mortality had not been reduced so very sharply, the use of roentgen therapy in these cases would be justified by the relief of anxiety and discomfort experienced by the patients. All Type II and III pneumonias treated with roentgen rays have recovered.*

REFERENCES

1. Fried, C., and Heidenhain, L. Roentgen irradiation in inflammations. *Arch. f. klin. Chir.*, 1924, *133*, 624–665.
2. Heidenhain, L., and Fried, C. Roentgen irradiation in inflammations. *Klin. Wchnschr.*, 1924, *3*, 1121–1122.
3. Fried, C. Artificial pneumonia and its irradiation. *Strahlentherapie*, 1937, *58*, 430–448.
4. Powell, E. V. Radiation therapy of lobar pneumonia. *Texas State J. Med.*, 1936, *32*, 237–240.
5. Cole, R. Treatment of pneumonia. *Ann. Int. Med.*, 1936, *10*, 1–12.
6. Fried, B. M. Allergic inflammation of the lungs. *Arch. Path.*, 1934, *18*, 865–877.
7. McIntire, F. T., and Smith, J. H. X-ray therapy in treatment of pneumonia. *Texas State J. Med.*, 1937, *33*, 422–426.

* Additional Note. February 14, 1939. Two hundred and thirty-one cases have now been treated, of whom 16 have died; mortality rate, 7 per cent.

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STRIKING REGRESSION OF GENERALIZED SUBCUTANEOUS AND VISCERAL METASTASES OF MALIGNANT MELANOMA (MELANOBLASTOMA) FOLLOWING INTENSIVE HIGH VOLTAGE ROENTGEN IRRADIATION OF THE PITUITARY GLAND*

By PALMER E. WIGBY, M.D., AND M. HILL METZ, M.D.
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THE melanophore-expanding hormone, which serves a useful function in amphibia and some fish, is found in the highest concentration in the intermediate lobe of the pituitary gland. This principle has also been found in the human hypophysis,[1,2,3] but no specific physiologic rôle can be attributed to it. It occurred to one of us (M.H.M.) that there might be some intimate connection between this chemical activator (increased amount) and the abnormal growth and reproduction of melanin-containing cells.

No form of therapy is known which alters the fatal course of metastatic melanoma, so with the above thought in mind, we decided to employ heavy roentgen radiation over the pituitary body. We do not know that the patient in the case report which follows will live very much longer, or that the next case we treat will behave similarly. We felt, however, that the succession of events was of sufficient interest to warrant publication, and we hope this will represent the preliminary report of a new approach in the treatment of malignant melanoma.

CASE REPORT

S. D. D., a white male, aged forty-three, traveling salesman, was first admitted to Parkland Hospital on June 12, 1938. The patient related that he had always had a mole on the right side of his face just in front of the upper portion of the right ear. Six to seven years previously he believed it began to enlarge slightly. Four years before, Dr. Everett Fox of Dallas, Texas, performed a wide removal, followed by a large dose of superficial roentgen therapy to the scar. The microscopic diagnosis of the excised lesion was melanocarcinoma. The patient was in good health until one year previous to present admission, when he noted some loss of energy and fatigue on effort. Four months ago he had noticed a few scattered lesions over the abdomen and arms, which he thought to be hives. These, however, completely disappeared. Two weeks before admission there had been fatigue, generalized aching, and at that time he first noted nodules in various places which increased in size and number. At the time of admission, the patient complained of weakness, loss of weight and appetite, and generalized subcutaneous nodules.

There had been no previous illness of significance and the family history was non-contributory.

Physical examination revealed a white male of middle age who was in no apparent discomfort, but who was rather decidedly undernourished and weak. Palpation at almost any part of the entire skin surface disclosed hard, movable nodules of all sizes up to 2 cm. in diameter beneath the skin. The largest nodule appeared to be on the scalp, with the next largest between the scapulae. These measured at least 2 cm. in diameter. The pupils were equal and regular and reacted to light and accommodation. The mucous membranes were moderately pale. The patient's teeth had a fairly healthy appearance. There was no evidence of adenopathy on either side of the neck or elsewhere on the body. The heart was essentially negative. Neither the liver nor the spleen was palpable. There was no definitely palpable abdominal mass at any point. Some of the subcutaneous nodules were quite tender.

On admission, the examination of the blood was as follows: erythrocytes, 4,200,000; leuko-

* From the Department of Radiology, Parkland Hospital, and the Department of Medicine, Baylor University College of Medicine, Dallas, Texas.

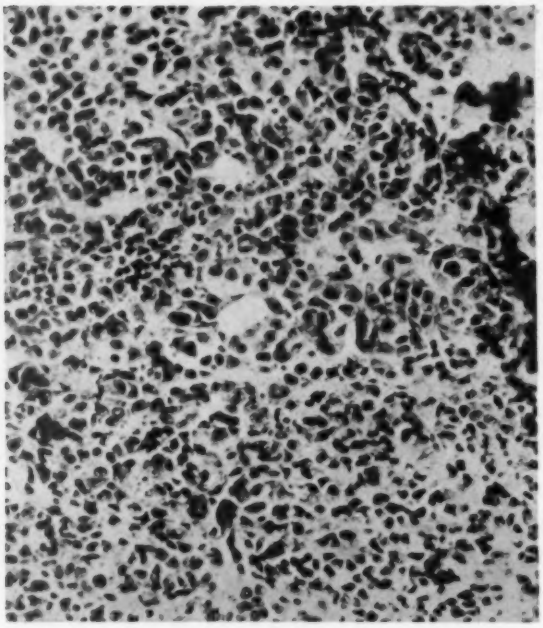

Fig. 1. Photomicrograph (400×) of section of subcutaneous nodule removed June 13, 1938. Numerous mitoses are seen.

cytes, 6,800; polymorphonuclears, 64 per cent; lymphocytes, 28 per cent; eosinophiles, 4 per cent; stabs, 4 per cent. The Wassermann reaction was negative. The fasting blood sugar was 72 mg. per 100 cc. and two hours after breakfast was 87 mg. per 100 cc. These examinations were repeated on two subsequent occasions, and this evidence of increased glucose tolerance did not change after roentgen therapy. The basal metabolic rate was essentially normal, being +4 and +8 per cent on two occasions. Gastric analysis demonstrated free HCl 38°, combined acids 38°, and total acids 76°. Occult blood was not found.

The pathologist's report of the microscopic section (Fig. 1) of nodule removed from the skin June 13, 1938, was as follows: Section shows a normal skin with normal appearing subcutaneous tissue, in one area of which there is a mass composed of extremely anaplastic poorly differentiated, neoplastic cells which appear to be more of the epithelial type. The nuclei vary markedly in size, shape and staining ability. In several areas there has been deposition of a melanin pigment. *Diagnosis:* Malignant melanoma in subcutaneous tissues.

A roentgenogram of the chest (Fig. 2) made on June 13, 1938, demonstrated a rather large lesion in the upper right lobe which had the typical appearance of a metastatic malignant process, and unquestionably representing metastatic melanoblastoma.

At first the amount of splenic extract* derived from 325 grams of fresh spleen was given in divided doses during the period from June 15, 1938 to July 8, 1938. The patient showed gradual decline during this period and the number of erythrocytes dropped to 3,800,000. He was given 750 r, using 200 kv., with 0.5 mm. Cu and 2 mm. Al filtration, to the chest lesion anteriorly, and a similar amount posteriorly from June 20 to 28. A checkup film of the chest on July 8, 1938, failed to show any change in the size of the chest lesion. Pituitary irradiation was begun on July 2, 1938. The irradiation was given with roentgen rays generated at 200 kv. constant potential, at a distance of 52 cm. and filtered by 2 mm. Cu plus 0.5 mm. Al. The size of the portal was 5×6 cm. and 207 r was used as the daily dose. Three portals were treated alternately. The treatments were discontinued on August 3 at which time each of the three portals had received approximately 1,560 r.

The patient's clinical course during the period of the pituitary roentgen irradiation is very interesting. He began to feel definitely better just a few days after the beginning of the treatment. A nurse's note on the chart recorded on July 7 states that the patient is sitting up in bed and listening to the radio, and quoted from

Fig. 2. Roentgenogram of chest made June 13, 1938. A rather large lesion is seen underlying and slightly below the level of the anterior end of the first rib.

* Armour Laboratories kindly furnished the splenic extract.

the patient to the effect that he was feeling fine. The patient himself called attention to the fact that the nodules were beginning to get smaller at about this time, but none of the hospital's personnel made any definite record of this until July 23. The patient's attendants, however, noted decrease in size and number of nodules very early in the course of his roentgen therapy. Because of the hopelessness of his condition complete blood studies were not obtained earlier, and it was for this reason photographs were not made before a late date. It was noted, however, that on August 1 the number of erythrocytes had risen to 4,200,000. The weight on admission was 108 pounds, and it was recorded early in July that the patient's weight had dropped to 102 pounds. The weight on discharge (Aug. 3, 1938) was 107 pounds. There had been rather marked subjective improvement during the last ten days in the hospital. The patient slept very well, where earlier during his stay in the hospital he had been quite restless and sedatives were necessary for sound sleep. His appetite had improved markedly, and his strength on discharge appeared to be good. It was noted that many nodules disappeared during the last weeks in the hospital, and there were just a few remaining on discharge. All nodules, according to the patient, had decreased in size, and all tenderness had disappeared. On August 13, 1938, the patient was observed again and at this time his weight was 110 pounds and only about a dozen small nodules could be found on the abdomen over an area in which previously about one hundred nodules had been counted. The patient was last

Fig. 3. Roentgenogram of chest made August 20, 1938. The nodule seen in upper lobe in Figure 2 has decreased at least 50 per cent in size.

Fig. 4. Photograph taken August 2, 1938, while nodules were rapidly disappearing.

Fig. 5. Photograph taken September 2, 1938, shows decrease in size of all nodules noted on August 2 and complete disappearance of many. Note particularly the one marked by the arrow in Figure 4. Also note increase in weight.

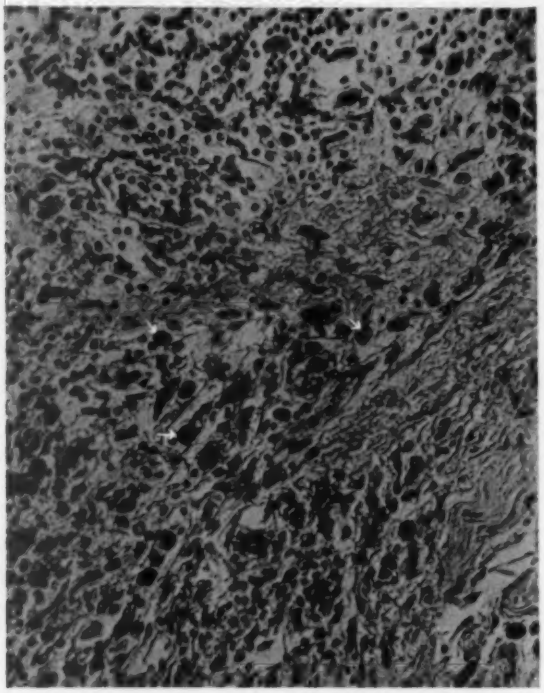

Fig. 6. Photomicrograph of section of one of residual nodules removed August 27, 1938, demonstrates histopathological regression as described in the text. Phagocytic cells (indicated by arrows) completely obscured by ingested melanin.

seen on August 20, 1938, at which time his erythrocytes numbered 4,500,000, white count, with a differential entirely normal, and a hemoglobin (Sahli) of 91 per cent. A roentgenogram (Fig. 3) of the chest shows the original nodule beneath the tip of the first right rib anteriorly to have decreased at least 50 per cent in size. The patient relates that he continues to improve and that he has been carrying on his former occupation to some extent. Figures 4 and 5 show the appearance of the anterior surface of the chest and abdomen on August 2 and September 2, 1938, respectively. His weight on September 2 was 114 pounds.

The microscopical section (Fig. 6) from skin biopsy on August 27 shows a normal covering epithelium with underlying subcutaneous tissue in which there is an area of recent young fibrous tissue proliferation. This area shows many fibroblasts with infiltrating lymphoid and plasma cells. There is a large amount of melanin present within the granulation area as well as in the loose portions of the adjacent mature connective tissue. The melanin is located within the cytoplasm of macrophages for the most part, but portions are in cytoplasm of endothelial cells as well as free in the intercellular spaces. No neoplastic cells can be definitely identified. *Pathological diagnosis:* Chronic inflammatory granulation tissue with marked melanin deposition.

Examination of all microscopical sections was made by Dr. A. B. Cairns, Pathologist, Parkland Hospital.

Additional Note: The patient was seen late in February, 1939, at which time his condition was excellent. He has resumed his normal activities; his physical examination is entirely negative; a roentgenogram of his chest is essentially negative, and his weight is 126 pounds.

COMMENT

One explanation of the effect of the roentgen ray in this case may be that one or more of the principles of pituitary secretion were definitely decreased or completely eliminated from the circulation by the pituitary irradiation. This secretion is apparently not only necessary for growth and reproduction of the melanoblast, but also for abnormal numbers of them to remain viable. It may therefore be essential to irradiate the pituitary at frequent intervals in order to be certain that the secretion of the responsible cells is continuously decreased or eliminated from the general circulation.

SUMMARY

1. A case is reported in which heavy roentgen irradiation of the pituitary gland apparently produced almost complete disappearance of extensive generalized metastases from malignant melanoma and rehabilitated a patient who was not far from death when first seen.

2. An explanation for the possible effect of the irradiation is included.

Addendum. Since submission of this paper for publication on September 10, 1938, four more cases of generalized metastatic malignant melanoma have been treated by pituitary roentgen irradiation in the same manner as the above case. A finding which all of these patients had and which our patient in the above report did not have was

extensive regional glandular metastases. None of the last four treated showed significant response, except one case which had definite relief of pain for about three months. All these cases were far advanced when first seen and had extensive distant metastases. The regional glandular involvement is the important difference in the one which recovered and those not responding. One other consideration is the possible influence that the spleen extract had on the neoplastic process. It is thought that spleen extract may contain an inhibitor factor as deduced from the fact that the spleen seldom receives malignant metastases when all other organs may be involved. We felt that the successful result was a radiation effect inasmuch as the equivalent doses of spleen given were small. Further studies on the effect of spleen extract on the viability and growth of malignant tumors are being made here by one of the authors (P.E.W.), and the results will be reported at a later date.

REFERENCES

1. Ehrhardt, K. Klinische und tierexperimentelle Untersuchungen über das Melanophorenagens des Hypophysenhinterlappens. *Arch. f. Gynäk.*, 1932, *148*, 265–270.
2. Zondek, B., and Krohn, H. Hormon des Zwischenlappens der Hypophyse (Intermedin). II. Intermedin im Organismus (Hypophyse, Gehirn). *Klin. Wchnschr.*, 1932, *11*, 849–853.
3. Zondek, B., and Krohn, H. Hormon des Zwischenlappens der Hypophyse (Intermedin). III. Zur Chemie, Darstellung und Biologie des Intermedins. *Klin. Wchnschr.*, 1932, *11*, 1293–1298.

CANCER OF THE ESOPHAGUS*

SOME ETIOLOGICAL CONSIDERATIONS

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ALTHOUGH one now finds in the literature an occasional report of a case of carcinoma of the esophagus, free of disease five years after aggressive radiation therapy, this type of cancer remains almost 100 per cent fatal, despite the fact that in most other fields better salvage rates are resulting from technical and clinical improvement in treatment. Until such a time as there is a more satisfactory therapeutic agent, we are continuing to employ in the treatment of this disease roentgen rays and radium, in divided doses. This treatment definitely prolongs life. At the same time we are forcefully emphasizing the importance of early diagnosis and are directing our efforts toward a clearer understanding of the etiology of this disease and its treatment and prevention. If cure in any considerable proportion of cases is improbable, then surely prevention is most essential and desirable.

The fundamental factor or factors responsible for the neoplastic response of certain tissues to a given set of stimuli are still not at all well understood, but for certain special groups of tumors well-established and fairly definite predisposing factors are known. In other words, the nature of the neoplastic process is not well understood, but the special etiologies of many tumors are fairly well recognized. This report does not involve discussion of the various theories as to the nature of cancer in general and of the esophagus in particular, but rather presents a minute review of the special combinations of etiological factors which are responsible for the development of this fatal disease.

The material upon which the report is based consists of 771 cases of cancer of the esophagus treated on the Head and Neck Service at the Memorial Hospital. A review of these case histories, and a more detailed study of a group of 16 cases, in which a definite second primary malignant neoplasm occurred, lead to some general observations as to the cause of this disease which may prove of value in suggesting measures for its prevention.

HEREDITY

Even a large series of cases helps very little in settling the question as to the rôle played by heredity in the production of cancer. Most patients are poorly informed on this matter and consequently the records are incomplete. But surely one inherits certain organic characteristics and peculiarities, and the effects of standard types of food, customs of eating, climate, habits of life, mental outlook and occupation may definitely predispose a group of individuals to certain types of cancer. With this in mind it should be noted that a large percentage of the patients in this series are Russian or Polish Jews of a station in life definitely below average, and further, that 9 out of 10 patients with this disease are in the lower middle class socially, and on the whole financially insecure.

There is no evidence of Mendelian inheritance in human cancer; in all probability every human being inherits a certain cancer susceptibility, but only in certain instances is this tendency pronounced and the disease does not develop until other exciting factors are brought into play. While cancer of the esophagus is not hereditary, still certain congenital anomalies such as the abnormally short esophagus, esophageal diverticula, strictures, and so

* Read at the Twenty-third Annual Meeting, American Radium Society, San Francisco, Calif., June 13–14, 1938.

forth, may very definitely predispose to the development of cancer. A nervous hysterical temperament is usually inherited and these conditions have been shown to be factors in causing cardiospasm, esophagitis, and occasionally cancer.

TRAUMA

In general, a single severe mechanical trauma seldom produces tissue changes leading to the development of cancer; however, in the esophagus rough instrumentation leading to laceration of the walls may result in scarring and narrowing of the lumen. This may be followed by esophagitis and food stasis due to narrowing, and eventually neoplastic changes may occur.

A much more frequent etiological factor is the repeated mechanical trauma of poorly masticated food such as occurs routinely in cases where the patient has many teeth missing, poor or painful teeth, intraoral sepsis, or when, because of expense, an attempt is made to "get along" without dentures. Badly kept teeth, intraoral sepsis, and ill-fitting plates tend to cause hasty and incomplete mastication which makes it necessary for the esophagus to handle masses of food which are large and hard. This leads to trauma, especially at the points of physiological narrowing and results in inflammation, spasm, stagnation, esophagitis, ulceration, and possibly cancer.

Thermal irritation is probably the most constant factor predisposing to cancer of the esophagus. The drinking of copious amounts of excessively hot tea is a history frequently obtained from Russian-born patients coming to Memorial Hospital suffering from cancer of the esophagus.

Craver,[3] in his detailed report on the etiology of cancer of the esophagus, stressed the importance of excessive use of alcohol and tobacco, dental disease, heat of ingested food and drink, excessive seasoning of food, coarseness of food, and irregularity of meals. The high frequency of chronic constipation associated with a tendency toward a restricted water intake was an important finding in his cases. A history of sinusitis and tonsillar infections was rare, and arteriosclerosis was seldom detectable on physical examination of the patients he studied.

Ewing[4] believes that anomalies of structure of the esophageal mucosa may be predisposing factors in the production of cancer. It is certain that pressure plays a rôle, as it is well known that the malignant changes tend to occur at points of physiological narrowing, and considerable emphasis is given this theory by the investigations of Benciolini.[1] He found definite thickening of the mucosal epithelium, round cell infiltration in the submucosa and a proliferative reaction in the basal layer disrupting the basal membrane at the sites of physiological narrowing in 18 per cent of 44 cases of post-mortem study of the esophagus.

Partial obstruction of the esophagus may be caused by extrinsic pressure, most commonly by aneurysm, and this condition has been noted as a factor predisposing to malignant degeneration. By far the most common form of chronic partial esophageal obstructions are the diffuse spasms, the cardiospasms, and the partial gastric hernias. These conditions are quite common in any large endoscopic clinic and, although there are numerous reports of the development of cancer of the esophagus in such cases, the direct relationship is difficult of proof—only one such instance occurs in this series of 771 cases.

Fleiner and Wohlwill[10] suggest that cardiospasm and dilatation predispose to the development of cancer. In one case reported by the latter there was a definite neurotic background and a persistent cardiospasm for seventeen years preceding the development of the cancer, suggesting the neurotic setting as a predisposing factor in the production of esophageal cancer.

Acquired abnormalities may produce narrowing and partial obstruction of the esophagus. The most frequent offender in this class is the lye burn of infancy. When cancer develops in such cases it often starts

at the site of a thick scar with adjacent narrowing of the lumen, usually at the upper third. A period of more than twenty-five years usually intervenes between the ingestion of the lye and the development of the cancer. This time interval is also characteristic of scar cancer developing elsewhere in the body.

Partial obstruction and stasis of food may be caused by esophageal diverticula, and Vinson and Kennedy[8] have reported 3 such cases in which cancer of the esophagus developed at the site of the diverticulum. A benign esophageal polyp degenerating into a neoplasm was reported by Targett,[7] and independently by Schirmer.[6]

On the other hand, partial obstruction caused by such benign conditions as peptic ulcer of the esophagus and the vitamin deficiencies such as Plummer-Vinson's disease have not in a single case in the present series preceded the development of cancer. Tuberculosis and syphilis have been found to coexist in the esophagus, but causal relationship is very questionable. Syphilis was present in 7 per cent of our cases, about the percentage expected in the general population.

The importance of esophageal leukoplakia as a precancerous process is difficult to evaluate, because it is a relatively common condition often seen when cancer is not present. On the other hand, cancer of the esophagus, at the stage it is usually diagnosed, routinely causes a certain amount of obstruction and food stasis which in turn produces inflammation, chronic irritation and leukoplakia. Having seen several early cases of cancer without obstruction but associated with an advanced degree of leukoplakia, I have the clinical impression that leukoplakia precedes esophageal cancer in about the same percentage of cases as one finds it to be a precursor of the cancers in the intraoral group. And the same causative factors may possibly enter into its production in both regions.

Having the above impression in mind and hoping to shed some light on the rôle played by predisposing factors in the causation of cancer of the esophagus, I undertook a search of our records for instances of double primary cancer. In the present series of 771 cases of cancer of the esophagus, a group of 16 cases of double primary malignant disease was collected. This is an incidence of 2.07 per cent and is higher than that reported by Warren and Gates[9] who gathered statistics on 29,740 cases of malignant disease and noted multiple primary cancer in 546 instances, or 1.84 per cent.

The relatively high incidence in our series becomes more important when we realize that not a single patient with cancer of the esophagus lived long enough to develop a second cancer. That is, the cancer of the esophagus always developed simultaneously with, or at some time after, the cure of another primary cancer. The incidence in this series would be higher, but we discarded, for statistical purposes, 5 additional cases because of lack of definite histological proof of one primary lesion.

Billroth,[2] in 1869, reported the first case of multiple primary malignant disease and suggested certain criteria for establishing the authenticity of these lesions. His postulates were too severe and the following criteria of Goetze[5] are now generally accepted and were used in selecting the cases in this series: "The macroscopic and microscopic appearance of the tumors must be that of the usual tumors of the organs involved; exclusion of metastases must be certain; diagnosis may be confirmed by the character of the metastases in each case."

A careful search of the literature reveals only 40 reported cases of double primary cancer involving the esophagus. In 16 of these the second organ involved was the stomach and I suspect were instances of cancer of the abdominal portion of the esophagus with extension into the cardiac portion of stomach, or perhaps submucous lymphatic metastasis. In our series not a single case of two separate cancers of the esophagus occurred, although we had a number of cases showing extension into the stomach as well as metastatic out-

croppings on the esophageal mucosa at some distance from the primary lesion.

Of the present series of 16 cases, the second primary growth was intraoral cancer in 14 instances; that is, 87.5 per cent of the cancers were confined to the upper food and air passages and the esophagus. From this fact it seems reasonable to suspect that the same predisposing etiological factors were concerned to some extent with the inception of cancer in both localities.

TABLE I

MULTIPLE CANCER

771 cases of esophageal cancer—16 double cancers, 2.07%
Sex: males, 16; females, 0
Age: youngest, 45 yr.; oldest, 73 yr.; average, 59.7 yr.
History of familial cancer: 6 cases (37.5%)
Wassermann: positive, 0; negative, 10; not stated, 6

Location of esophageal cancer:

Upper third	10 cases
Middle third	2 cases
Lower third	4 cases

Location of other primary cancer:

Lip	1 case	14 (87.5%) intraoral cancers
Floor of mouth	6 cases	
Mucosa of cheek	2 cases	
Tongue	2 cases	
Mandible	1 case	
Epiglottis	1 case	
Larynx	1 case	
Skin of face	1 case	
Skin of hand	1 case	

The group is composed of 16 males and no females. The youngest was forty-five years of age and the oldest seventy-three; the average age was 59.7 years. The average age of the males with a single cancer of the esophagus is 57.4. These figures lend support to the general impression that double cancers occur later in life than do single lesions.

In this large series of cancers of the esophagus, the lesion is located most frequently in the lower third of the organ, but in this series of double cancers, 66 per cent of the esophageal growths were located in the upper third of the organ.

In one case the teeth were good, but in all the other cases the intraoral condition was unsatisfactory. The Wassermann reaction was reported as negative in the 10 instances in which it was recorded.

A history of familial cancer was noted in 6 cases, or 37.5 per cent. In 5 instances (31 per cent) the two primary malignant diseases were discovered simultaneously. The interval between the discovery of the first and second tumors ranged from six months to seventeen and one-half years.

The cause of death in all cases of this series of double primary malignant disease was cancer of the esophagus.

In 5 instances (31 per cent) the pathologist's report of the histological material removed from the esophageal lesion was squamous cell carcinoma, Grade 3, relatively radiation sensitive. In a former series of single cancers of the esophagus only 6 per cent were reported as Grade 3 radiation sensitive. It would seem as though double cancers tended to be of a higher degree of malignancy.

SUMMARY

1. The major predisposing factors in the causation of cancer of the esophagus are discussed on a basis of a series of 771 cases.

2. A group of 16 cases of multiple primary malignant neoplasms is selected from the above group.

3. Double cancer occurred in 2.07 per cent of the cases.

4. In 87.5 per cent of the cases the second primary growth was located in the upper air and food passages.

5. Familial history of cancer was obtained in 6 cases, or 37.5 per cent of the total.

6. Multiple cancers tend to occur at a later age than do single cancers of the esophagus.

7. It seems safe to assume that the same predisposing factors active in the causation of intraoral cancer also play a part in causing cancer of the esophagus.

8. Histological examination of the esophageal lesion in this series of double cancers points definitely to a higher degree

of malignancy than was present in a large series of single cancers.

9. It is suggested that adequate measures to clear up intraoral sepsis and dental troubles would probably not only reduce the incidence of intraoral cancer, but at the same time definitely reduce the number of patients developing a fatal neoplasm of the esophagus.

10. The occurrence of coincidental multiple primary malignant disease is too frequent to be attributed solely to chance.

REFERENCES

1. Benciolini, F. Il comportamento dell'epitelio esofagio nei vecchi in corrispondenza delle stretture anatomiche considerate quali sedi di cancro. *Arch. ital. di otol.*, 1930, *41*, 170–208.
2. Billroth, T. General Surgery. Translated by C. E. Hackley. D. Appleton & Co., New York, 1889, p. 765.
3. Craver, L. F. Clinical study of etiology of gastric and esophageal carcinoma. *Am. J. Cancer*, 1932, *16*, 68–102.
4. Ewing, J. Neoplastic Diseases. Third edition. W. B. Saunders & Co., Philadelphia, 1928.
5. Goetze, O. *Ztschr. f. Krebsforsch.*, 1913, *13*, 281.
6. Schirmer, O. *Arch. f. Verdauungskr.*, 1923, *31*, 365.
7. Targett, J. H. Fibrous polypus of the esophagus invaded by epithelioma. *Tr. Path. Soc., Lond.*, 1895, *46*, 48.
8. Vinson, P. P., and Kennedy, F. S. Association of benign and malignant lesions of esophagus. *Am. J. M. Sc.*, 1933, *186*, 660–665.
9. Warren, S., and Gates, O. Multiple primary malignant tumors. *Am. J. Cancer*, 1932, *16*, 1358–1414.
10. Wohlwill, F. Quoted by Vinson and Kennedy, ref. 8.

Vol. 41, No. 3

RESULTS OF ROENTGEN THERAPY IN FIFTY-ONE CASES OF PRIMARY INOPERABLE CANCER OF THE OVARIES*

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DURING the years of 1923 to 1934, 51 cases of primary inoperable cancer of the ovaries were admitted for roentgen treatment. Of these, 31 were so far advanced that only a laparotomy could be performed to establish the diagnosis. In the remaining 20 cases it was possible to remove, aside from a part of the tumor masses, the primary location of the cancer. This was found to be in 8 cases the right ovary, in 3 cases the left, and in 9 cases both ovaries. Of these, 4 recurred so rapidly that at the time of admission for roentgen therapy large masses were found by palpation. The microscopical examination of the specimen revealed in 2 cases embryoma, in 11 cases carcinoma, and in 38 cases adenocarcinoma.

According to Norris and Murphy, the incidence of ovarian tumor in gynecological cases is 7.7 per cent; according to Lippert 1.6 per cent, and according to Gurlt 8.5 per cent. The percentage of malignant degeneration of ovarian tumors varies with the different authors from 7.7 per cent to 24.5 per cent, the average being 20 per cent. This indicates that 1 out of every 5 cases of ovarian tumor is malignant. In fact, this figure is even higher if all the cases of adenoma are included, which, though being diagnosed as such, contain within their structure small nests of adenocarcinoma. Ewing quotes Pfannenstiel, who maintains that 50 per cent of papillary cystic tumors reveal adenocarcinomatous structure in at least some portion of the growth, but most of such tumors being encapsulated, are successfully removed. The percentage of bilateral involvement is very high. Ewing is of the opinion that the majority of carcinomas of the ovaries are originally bilateral or soon become so. Metastases occur very early. They travel most frequently by dissemination through the peritoneal cavity, and also through the lymph and blood channels.

Ascites was present in 41 cases of this series. The youngest patient treated was twenty-two years, the oldest seventy-three years old at the time of admission. The greatest number of patients was in the decade between fifty-one and sixty years of age. Ten patients were single. Of the 41 married, 11 had no children and 30 had one or more children.

TABLE I

AGE INCIDENCE AND HISTOLOGY

Years	Embryoma	Carcinoma	Adenocarcinoma	Total
20 to 30	1	—	4	5
31 to 40	1	1	3	5
41 to 50	—	1	11	12
51 to 60	—	8	15	23
61 to 70	—	1	4	5
71 to 80	—	—	1	1
Total	2	11	38	51

It is unfortunate that the initial symptoms are not more significant. They consist, first of all, of pain in the abdomen and loss of appetite. Next come the enlargement of the abdomen, backache and disturbance in menses, function of bowels and micturition. Many times only the increasing cachexia prompts the patient to seek medical advice. For this reason only about 50 per cent of all cases of ovarian cancer come early enough to undergo a radical operation, and of these only 25 per cent are alive after five years. Heyman reports 30 per cent of the cases with unilateral and

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

considerably less with bilateral involvement. Wintz summarizes the statistics of four German clinics and averages 25 per cent in the radically operated cases. If all operable as well as inoperable cases are included, the percentage of five-year cures with surgery drops to 10 per cent. These discouraging figures explain why one turned to radiotherapy as an aid to surgery in order to increase the number of cures. Many early reports were encouraging, such as that of Eymer in 1912, von Franqué in 1913, Fleischman in 1915, Aubert, Walthard, Seitz and Wintz in 1920, and many others. The first American article on results of combined surgery and radiotherapy reporting 24 cases were written by Keene, Pancoast and Pendergrass in 1927. In 1929 Pfahler and Gershon-Cohen reported beneficial results in 3 inoperable cases. In 1930 Jacobs reported good results in 3 cases. Harris and Payne in 1935 came to definite conclusions as to the value of radiotherapy following operation by comparing 38 cases treated by the combined method with 51 cases only operated upon. From the results of the investigation of 92 cases, Murphy in 1935 suggested that the treatment should consist of removal of both ovaries followed by irradiation in large tumor doses. All authors agree that the response to radiotherapy is better if as much of the tumor mass as possible is removed together with the primary site of the cancer. Therefore, they classify their cases not only as to type of malignancy but also as to: (*a*) radically operated upon; (*b*) primary growth removed with small tumor masses remaining; (*c*) palliative operation only because of general peritoneal involvement.

TREATMENT

The treatment of ovarian cancer is first of all surgical. Only after the abdomen has been opened and the tumor microscopically examined can the extent and exact nature of the growth be ascertained. The inspection of the abdominal cavity at operation offers valuable information to the radiologist in outlining his future plan of treatment. How much of the tumor should be removed must be estimated by the involvement of the organs as well as by the general condition of the patient. Some authors advise the removal of the uterus for the same reason that both ovaries and adnexa are removed. Heyman and Schroeder and also Murphy leave the uterus intact for the possible insertion of radium. Seitz removes the uterus and inserts the heavily filtered radium in the vaginal vault. As soon as possible following the operation and before tumor and ascites have a chance to recur, the patient should receive radiotherapy. The importance of this point cannot be emphasized enough. Much valuable time has been lost by postponing the treatments. In at least 4 cases of this series the patients, preferring to wait until they were stronger, finally came for treatment in a hopeless condition.

Radium is best inserted in the uterus at the time of the operation. According to the various authors, the dose averages from 3,000 to 5,000 milligram-hours. No patient of this group has received radium in addition to the roentgen treatments. Murphy gives an intrauterine dose of 1,200 to 2,400 mg-hr. and combines this with radium pack or roentgen therapy.

In the radically operated cases, the area to be irradiated for postoperative prophylactic treatment may be confined to the lower pelvis. As soon, however, as there are transplants in the peritoneum, or the case is otherwise advanced, the entire abdomen must be subjected to a thorough course of roentgen therapy.

Some cases respond to a relatively small total dose. To this group belong the cases reported in the early era of roentgen therapy. All other cases require much higher doses. To apply these satisfactorily is indeed one of the most difficult tasks in radiotherapy. The fields must be arranged in such a way that a homogeneous distribution of the radiant energy throughout the abdomen results. Because of the large area irradiated, the general condition of the patient together with the blood picture

must be carefully watched, and the treatments arranged accordingly. All possible assistance by medication and general care must be given the patient to insure the maintenance of her strength and vitality.

Before any therapy is started the plan of treatment is carefully outlined. The size and number of fields, their relation to each other and the proper focal skin distance vary with the measurements of the patient. For patients with comparatively flat abdomen two anterior, two posterior and two perineal fields, one anterior and one posterior, are used. Where the abdomen is distended, the two abdominal fields are subdivided into four, with the central rays coming from the right and left anterior superior, and the right and left anterior inferior directions. All central rays converge in the middle of the abdominal cavity with the fields overlapping. The posterior fields may be subdivided in the same manner if necessary. The distance is from 50 to 80 cm. The kilovoltage is 200, and the filter is 1 mm. of copper plus 1 mm. of aluminum. The size of the individual doses and the interval between them must be determined by the general condition and the reaction of the patient. They vary between 200 and 400 r (measured in air), given daily or at intervals of from one to three days. The saturation method, as devised by Pfahler, is as closely adhered to as possible. If ascites has formed again, it is advisable to perform a paracentesis previous to the treatments in order to procure a better depth dose. The supreme law is not to force the course of treatments at the expense of the patient's resistance. A second or third series is given, if the condition of the patient makes this necessary.

RESULTS

Soon after institution of treatment a gradual reduction in the size of the tumor is noticeable. In some of the cases the shrinkage is next to miraculous and is exceeded only by that in lymphosarcoma. It is often remarkable how quickly the patients are relieved of their pain and suffering, regain their health and resume their social activities regardless of how poor their previous condition may have been. The formation of ascites is either partly or totally inhibited. Others, on the other hand, show a very slow regression of the tumor masses. Either the growth is less radiosensitive, or is resistant to the amount of radiation permissible by the poor general health of the patient. Sometimes it is impossible to make the growth disappear completely, still the patient remains in good condition. This fact is illustrated by a case of advanced adenocarcinoma, which is now, ten years after admission for treatment, in good condition, though a mass can still be felt in the lower abdomen. Heyman has operated on 5 such cases a second time, after the tumor had been reduced to operable size, and accomplished good results in 3 of the cases. Mizuta reports a case of inoperable cancer of the left ovary, which under roentgen treatment shrunk from the size of a child's head to that of a hen's egg. This was removed eight months later. The patient is at present in good condition.

I agree with Keene, Pancoast and Pendergrass that it is impossible to predict with acuracy what the effect of radiation therapy will be on any given patient. The nature and extent of the growth and its radiosensitivity, the general health of the patient and her response to the treatments are the guiding factors in making a prognosis. There were only a few cases which showed no response whatever to radiotherapy. They were, however, too ill and most of them died within one month after the operation. According to all authors, the cases of adenocarcinoma offer the best lasting results. Solid carcinoma, and especially embryoma, offer a poor prognosis. If the result of the first series of treatments remains unsatisfactory, it is usually not advisable to continue with radiotherapy.

Recurrences are frequent, for radiotherapy does not alter the tendency of ovarian cancers to recur. Cases have been described in which recurrences appeared

TABLE II

STATISTICS OF VARIOUS AUTHORS
(in percentage)

a. Surgery Alone

Author	Radical Operation				Inoperable			All Cases		
	Year		3 yr.	5 yr.		3 yr.	5 yr.		3 yr.	5 yr.
Glockner	1905	36		29						
Schäfer	1922	70		17				99		13
Zweifel	1922	—		30						
Linzenmeyer	1924	38		21						
von Peham and Amreich	1930	—		21				115		9.5
Mayer			42.8							
Harris and Payne	1935	27		85	24		12	51		51
Norris and Murphy	1935							125	40	
Stübler and Brandess	1923	40		47.5		25	0			

b. Surgery and Radiotherapy

Strassmann	1921							17		8.5
Schäfer	1922							20	50	
Heyman	1932	46		54		88	20	134		31.3
Meigs	1930					27	(3–10 tears)			
Ford	1928							59		28.8
Stübler and Brandess	1923	21		47.6		22	4.5			
Wintz	1932	9	77.7	75	8	20	33.3	(Group II)		
					49	40	25	(Group III)		
Harris and Payne	1935	1	100	100	3		43	(Group II)		
					1		17	(Group III)		
Schroeder	1934	27		60	9		11	(Group II)		
					20		5	(Group III)		
Murphy	1935							92		24

even many years after radical operation. The author has observed a case in which a recurrence took place eight years after what had appeared to be a complete cure.

Mrs. C., aged fifty-three, was treated for extensive recurrence in 1925 following the removal of the right ovary for cystic adenocarcinoma five months ago. The growth filled the entire abdomen up to the liver. Tumor and ascites disappeared completely within three months under roentgen treatment. The patient was in such good health that she refused to return for a second series or observation. Eight years later she noticed that the abdomen was becoming larger. On readmission she appeared already in very poor general condition. The abdomen was larger than ever before and was distended to almost the size of a full term pregnancy, partly due to the recurrence, partly to the ascites. The initial response to the roentgen treatments was not as good as eight years ago, but the tumor was reduced to about one-fourth of its previous size. Six months later it began to grow again very slowly and could be little influenced further. Then the general health of the patient declined very gradually. There was no pain or suffering until she died ten years after the first series of treatments.

As this case shows, recurrences are always more radioresistant than the original tumor. Their appearance marks usually the beginning of the gradual downward course of the patient's health. Unfortunately, however, the patients seem to be unaware of the seriousness of their condition and, instead of returning for roentgen treatment, when they notice the first symptom, they invariably wait until it is too late.

TABLE III

LENGTH OF LIFE AFTER TREATMENT

Group I. None Treated

Group II

	0	1	2	3	4	5	6	7	8	9	10	Years Total
Embryoma	—	—	—	—	—	—	—	—	—	—	—	—
Carcinoma	—	1	—	1	—	—	—	—	—	—	—	2
Adenocarcinoma	2	1	—	4	1	2	—	2	—	1	1	14
Total	2	2	—	5	1	2	—	2	—	1	1	16

Group III

Embryoma	2	—	—	—	—	—	—	—	—	—	—	—
Carcinoma	4	2	2	—	1	—	—	—	—	—	—	9
Adenocarcinoma	9	3	1	3	1	6	—	—	—	—	1	24
Total	15	5	3	3	2	6	—	—	—	—	1	35
Total All Groups	17	7	3	2	3	8	—	2	—	1	2	51

TABLE IV

RESULTS

a. Group I—omitted.

b. Group II

Tumor Type	Total	Well Over 3 Years	Per Cent	Well Over 5 Years	Per Cent	Well Over 10 Years	Per Cent
Embryoma	—	—	—	—	—	—	—
Carcinoma	2	1 of 2	50	0 of 1	0	—	—
Adenocarcinoma	14	11 of 14	78	6 of 10	60	1 of 1	(100)
	16	12 of 16	75	6 of 11	55	1 of 1	(100)

c. Group III

Embryoma	2	0 of 2	0	0 of 2	0	0 of 1	0
Carcinoma	9	1 of 9	11	0 of 8	0	0 of 7	0
Adenocarcinoma	24	11 of 24	46	7 of 21	33	1 of 10	10
	35	12 of 35	33	7 of 31	23	1 of 18	6

d. Groups II and III

Embryoma	2	0 of 2	0	0 of 2	0	0 of 1	0
Carcinoma	11	2 of 11	18	0 of 9	0	0 of 7	0
Adenocarcinoma	38	22 of 38	58	13 of 31	42	2 of 11	18
	51	24 of 51	47	13 of 42	31	2 of 19	10

The statistics compiled in Table II give a comparison of the end-results of surgery alone and of surgery followed by radiotherapy. They show that, even in the postoperative treatment of radically operated cases (Group I), there appears to be an increase in the percentage of five-year results. The advantage of the combined method becomes more evident, if one compares the figures of the results obtained in the treatment of inoperable cases (Groups II and III). In my series no case belonging to Group I is included. The highest mortality was found in the first year after admission for treatment. Seventeen cases, equal to one-third of the total 51, lived less than one year. Many of them received only insufficient treatment owing to their poor general and advanced local condition. No cases, even the most desperate ones, were refused treatment, as in these cases the relief of symptoms was very marked. In Group I, the results show for three years 75 per cent and for five years 55 per cent living. In Group II, the results are for three years 33 per cent and for five years 23 per cent. Taking both groups together, the results at three years are 47 per cent, at five years 31 per cent, and at ten years 10 per cent. The 2 cases of embryoma were greatly advanced and died within a few months after admission. Of the 11 cases of carcinoma only 1 lived four years after treatment. The most lasting results were obtained in the cases with adenocarcinoma, in which 1 lived nine years and 2 even ten years after treatment. The 13 cases living today all belong to the adenocarcinoma group. They constitute 25.5 per cent of the total series.

TABLE V

ALIVE TODAY

	Years								
	3	4	5	6	7	8	9	10	Total
Group I									
Embryoma	—	—	—	—	—	—	—	—	—
Carcinoma	—	—	—	—	—	—	—	—	—
Adenocarcinoma	2	—	—	—	1	—	1	—	4
Group II									
Embryoma	—	—	—	—	—	—	—	—	—
Carcinoma	—	—	—	—	—	—	—	—	—
Adenocarcinoma	3	—	4	—	1	—	—	1	9
Total	5	—	4	—	2	—	1	1	13

SUMMARY

Fifty-one cases of primary inoperable ovarian cancer were submitted to postoperative roentgen therapy. According to their microscopical structure, two were of embryoma, eleven of carcinoma and thirty-eight of adenocarcinoma type. The best results were seen in adenocarcinoma. The less advanced cases, in which the primary seat of the cancer could be removed with only small tumor masses remaining, give almost twice as good results (75 per cent for three years, 55 per cent for five years) as those cases in which only a palliative operation could be performed (33 per cent for three years, 23 per cent for five years). The total percentage of cases living three years after treatment was 47 per cent, of cases living five years after treatment was 31 per cent and of cases living 10 years 10 per cent. These figures show that radiotherapy following operation not only prolongs life by increasing the number of three- and five-year cures, but also relieves pain and discomfort in even the most advanced cases.

REFERENCES

1. Döderlein, A., Döderlein, G., and Voltz, F. Ueber das Uteruskarzinom und seine Strahlenbehandlung. *Acta radiol.*, 1926, *6*, 335–360.
2. Ewing, J. Neoplastic Diseases. W. B. Saunders Co., Philadelphia, 1928, p. 624.
3. Eymer, H. Beeinflussung von proliferierenden Ovarialtumoren durch Röntgenstrahlen. *Strahlentherapie*, 1912, *1*, 358–361.
4. Ford, F. A. Radiotherapy in carcinoma of the ovary. *Am. J. Obst. & Gynec.*, 1928, *16*, 1–11.
5. von Franqué, O. Strahlenbehandlung der Genitalkarzinome. *Strahlentherapie*, 1926, *21*, 187–221.
6. Harris, J. H., and Payne, F. L. Value of irradiation in the treatment of ovarian carcinoma. *Am. J. Obst. & Gynec.*, 1935, *29*, 88–93.
7. Healy, W. P. Experience with multiple dose roentgen therapy in malignant diseases of the uterus and ovaries. *Am. J. Obst. & Gynec.*, 1935, *30*, 613–624.
8. Hertzler, A. E. Surgical Pathology of the Female Generative Organs. J. B. Lippincott Co., Philadelphia, 1932, p. 176.
9. Heyman, J. Die Strahlentherapie als vollständiger oder teilweiser Ersatz der Operation bei der Behandlung von Karzinomen des Uterus, der Vagina and der Ovarien. *Strahlentherapie*, 1930, *37*, 254–265.
10. Heyman, J. Experiences with radiological treatment of cancer of uterus and ovaries. *Acta radiol.*, 1932, *13*, 329–333.
11. Hirsch, S. Beitrag zum Kapitel der Ovarialcarcinome. Inaug. Diss., University of Munich, 1920.
12. Holzknecht, G. An inoperable ovarian tumor treated by the method of E. G. Mayer. Am. J. Roentgenol. & Rad. Therapy, 1927, *17*, 332–334.
13. Jacobs, A. W. Carcinoma of the ovary. Am. J. Roentgenol. & Rad. Therapy, 1930, *24*, 63–65.
14. Jacobs, L. G., and Stenstrom, W. Carcinoma of the ovary. *Radiology*, 1937, *28*, 725–730.
15. Kean, A. Present status of radiation therapy in cancer of the ovaries. *Am. J. Surg.*, 1935, *27*, 425–429.
16. Keene, F. E., Pancoast, H. K., and Pendergrass, E. P. Value of irradiation in treatment of inoperable carcinoma of the ovary. *J. Am. M. Ass.*, 1927, *89*, 1053–1055.
17. Lazarus, P., Editor. Handbuch der gesamten Strahlenheilkunde. Bergmann, München, 1931, Vol. 2, p. 423.
18. Lippert, W. Beitrag zur Klinik der Ovarialtumoren. *Arch. f. Gynäk.*, 1904, *74*, 389–459.
19. Mayer, O. Klinik der Ovarialtumoren. From Halban and Seitz, L. Handbuch der Gynäkologie. Bergmann, München, 1934, Vol. 5, p. 2.
20. Mizuta, T. Ueber die Exstirpation eines inoperablen Ovarialpapilloms nach Coutard-'scher Röntgenbestrahlung. *Zentralbl. f. d. ges. Radiol.*, 1936, *23*, 294.
21. Montgomery, J. B., and Farrell, J. T., Jr. Results of post-operative x-ray therapy in carcinoma of the ovary. *Radiology*, 1934, *23*, 157–162.
22. Murphy, W. T. Primary malignant tumors of the ovary. *Surg., Gynec. & Obst.*, 1935, *61*, 289–305.
23. Norris, C. C. Five year end-results of treatment of carcinoma of the cervix, fundus, and ovary. *Surg., Gynec. & Obst.*, 1934, *58*, 458–459.
24. Norris, C. C., and Murphy, D. P. Malignant ovarian neoplasms. *Am. J. Obst. & Gynec.*, 1932, *23*, 833–837.
25. Norris, C. C., and Vogt, M. E. Malignant ovarian neoplasms. *Am. J. Obst. & Gynec.*, 1925, *10*, 684–692.
26. von Peham, H., and Amreich, J. Gynäkologische Operationslehre, S. Karger, Wien, 1930, p. 87.
27. Pfahler, G. E., and Gershon-Cohen, J. Generalized abdominal carcinomatosis of ovarian origin. Am. J. Roengenol. & Rad. Therapy, 1929, *22*, 447–451.
28. Schäfer, P. Therapie und Dauerheilung bei Ovarialcarcinomen. *Arch. f. Gynäk.*, 1922, *117*, 233–237.
29. Schroeder, C. Ueber unsere Ergebnisse bei der Behandlung des Ovarialkarzinoms. *Strahlentherapie*, 1934, *51*, 465–476.
30. Seitz, L. Die Röntgentherapie der bösartigen Genitalgeschwülste. In: Lehrbuch der Strahlentherapie, H. Meyer, Editor. Urban & Schwarzenberg, Berlin, 1929, *4*, 767.
31. Strassmann, P. Zur erweiterten Behandlung des Eierstocks-Bauchkrebses. *Deutsche med. Wchnschr.*, 1933, *59*, 402–404.
32. Stübler, E. and Brandess, T. Zur Pathologie und Klinik der Ovarialtumoren. *Würzb. Abhandl. a. d. Gesamtgeb. d. Med.*, 1923–1924, *21*, 249–360.
33. Vogt, E. Ueber die Röntgenbehandlung des inoperablen Ovarialcarcinoms. *Strahlentherapie*, 1929, *32*, 640–650.
34. Wintz, H. Die Röntgentherapie des Ovarialkarzinoms. *Strahlentherapie*, 1932, *44*, 201–226.
35. Zweifel, E. Ueber Bestrahlung unvollkommen operierter Ovarialkarzinoms. *Zentrabl. f. Gynäk.*, 1922, *46*, 1672.

CONTRIBUTIONS TO RADIUM THERAPY*

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IN THIS article an account is given of the work of the Radium Beam Therapy Research, London, during the past three years.

I. FIVE-GRAM RADIUM UNIT

In February, 1936, a 5-gm. unit was installed, in which the radium is loaded and unloaded automatically. Figure 1 gives a general view of the unit, the storage safe,

FIG. 1. General view of 5-gm. radium unit with pneumatic transference of radium, showing unit, storage safe, and flexible pipe connecting them through which the radium can be blown by air pressure.

and the flexible pipe connecting them, through which the radium can be blown to and fro by air pressure. Figure 2 gives a closer view of the unit. Details of the construction will be found elsewhere.[1] The 5 grams of radium are contained in 25 tubes which are packed into a steel bobbin. The bobbin is blown by air pressure from the storage safe through a flexible metal pipe, and enters the unit along its axis of rotation in the support. Then it passes through an internal tube which is curved twice, in planes at right angles, to prevent leakage of radiation along the path of the bobbin. As the radium approaches its final position it closes the air exit, and is brought gently to rest by the air which is compressed in front of it, and is firmly held by three spring detents. When the radium is accurately in position, a red lamp lights in the operator's room.

A protection of 10 cm. of lead is provided in all directions except immediately under the radium. The protection here amounts to 4.7 cm. of lead, which can be increased to 6.7 cm. lead, wherever conditions of treatment permit, by rotating an eccentric lead screen. A new tungsten alloy with excellent protection properties has been incorporated.

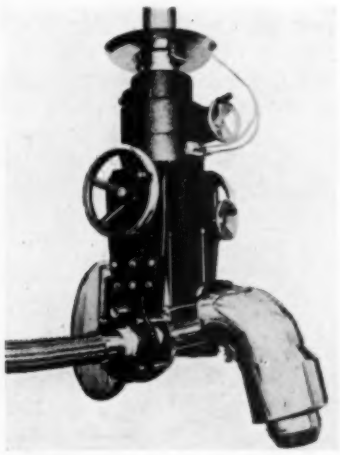

FIG. 2. Five-gram unit in use at the Radium Beam Therapy Research.

In case of a breakdown of the pneumatic system, a plug at the back of the unit can be removed, and the radium loaded by hand on a special handle.

The nozzles which fit on the front of the unit are interchangeable, given a choice of radium-skin distance and of field area. A directional caliper for accurate location of

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

the beam of gamma rays can be fitted on the front of the unit.[6]

The storage safe for the radium when not in the unit gives a minimum protection of 6 inches of lead. The radium container passes round an internal curved tube, comes to rest on a spiral spring, and lights a green lamp in the operator's room.

The apparatus is worked from a separate room. Figure 3 shows the control panel. The lamps at the top show whether the radium is in the unit, safe, or pipe. An electric clock is arranged to run while the radium is in the unit and so registers the total treatment time. The air blast is provided by an ordinary vacuum cleaner. The direction of the air flow is controlled by a two-way tap.

The unit has given satisfactory service since it was installed. There were certain difficulties at first, but these have now been overcome, and the apparatus works very consistently. A similar unit has been installed at the Royal Cancer Hospital (Free), London, and three more are in course of construction for use in Great Britain.

Fig. 3. Control panel for 5-gm. radium unit showing light signals and electric clock for integrating dosage.

II. TUNGSTEN ALLOY

The tungsten alloy[2,3,4] referred to consists of 90 per cent tungsten, 5 per cent nickel, and 5 per cent copper. It is made by mixing together the powdered metals, compressing them into slabs under high pressure and then heating strongly in an atmosphere of hydrogen. The resulting alloy is strong and hard but readily machineable and has a density of 16.5 to 17.0 gm./cm.^{3}

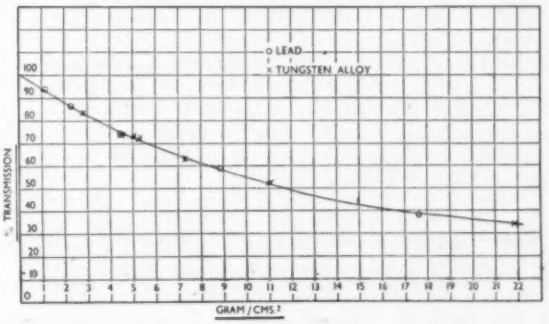

Fig. 4. Diagram comparing the transmission of gamma rays through lead and through the new dense tungsten alloy used for protection, which has a density of 16.5 to 17.0 gm./cm.^{3} and which is roughly one and a half times as effective as lead in absorbing gamma radiation.

In Figure 4 the absorption of hard gamma rays by the tungsten alloy and by lead are compared; percentage transmission is plotted against mass per cm.^{2} As will be seen, the points for lead (circles) and for the tungsten alloy (crosses) fall on the same curve, showing that for equal masses the absorptions of the two metals are the same, or that for equal thicknesses the tungsten alloy is about one and a half times more effective than lead.

III. PROTECTION MEASUREMENTS

During the past three years we have accumulated a good deal of information on protection. Our work was started in 1934 with one 5 gm. radium unit of the Stockholm pattern, in which the radium was removed by hand between treatments. Since this involved a certain exposure to radiation, we have kept daily records of the dose received by all members of the staff by means of Sievert's condenser-chamber technique. Figure 5 shows the types of condenser chamber we have found

suitable for this purpose; the upper three in the diagram each consists of a brass case containing a rod of aluminium insulated by amber and the lower one of graphited bakelite of a more convenient shape, which can be used for roentgen rays also. These condensers are carried by the staff while on duty. The results are summarized in Table 1.

TABLE I

ANALYSIS OF EXPOSURE OF STAFF TO RADIATION

Year	Radium Apparatus	Average Dose per Transfer of Radium	Total Dose in 3 Months (Average of All the Staff)	Permissible Dose in 3 Months (on Basis of 0.3 r/day)
1935	1–5 gm. unit (hand-loaded)	0.015 r	2.3 r	22.5 r
1937	2–5 gm. units (1 hand-loaded, 1 pneumatic)	0.016 r	3.9 r	22.5 r

It will be seen that in 1935, with one 5 gm. unit only, hand-loaded, the average dose of radiation received in carrying the 5 gm. of radium once to or from the safe was 0.015 r. The average dose over a period of three months was 2.3 r, whereas the permissible dose, calculated on a basis of 0.3 r per day, is 22.5 r. In 1937, with two 5 gm. units, one hand-loaded and one pneumatic, the dose per transfer was 0.016 r, practically the same as before, showing that no additional exposure arises from the pneumatic unit. In both cases the total dose of radiation received by any member of the staff over a period of three months is much less than the permissible dose. It is thus possible to work in safe with two 5 gm. radium units in a room 9×3.5 meters, although of course we do not recommend this.

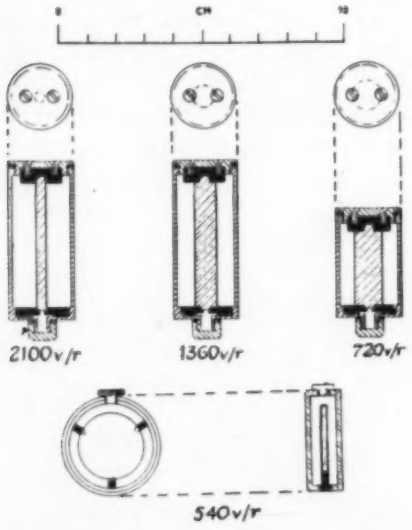

FIG. 5. Sievert condenser chambers carried by members of the staff for daily measurement of dosage received. Sensitivities indicated in volts per roentgen.

IV. "CONSTITUTIONAL" DOSAGE MEASUREMENT

The measurement of dosage in radium beam therapy falls into three classes: (1) dosage to the tumor, (2) dosage to the surrounding tissues, (3) dosage to the whole body. The first two problems have been solved in a satisfactory way at the Radium Beam Therapy Research, and the measuring of tumor dosage and tissue dosage are now part of the routine.[5,6] As regards the third problem, we are now working on a method of measuring directly the total energy absorption by the whole body. The principle of the method will be clear from Figure 6. If a beam of gamma rays is passed through a series of celluloid plates coated with graphite to make them electrically conducting, separated by small air gaps and connected alternately to a battery and

galvanometer, an ionization current will pass through the galvanometer. If the thicknesses of the celluloid plates and the air gaps are chosen so that the overall density is 1, then the absorption and scattering of the gamma rays will be the same as in a block of tissues of the same size, and it can be shown that the ionization current will be proportional to the total energy absorbed in this volume of tissues.

By building a life-sized model of the body with celluloid sheets in this way

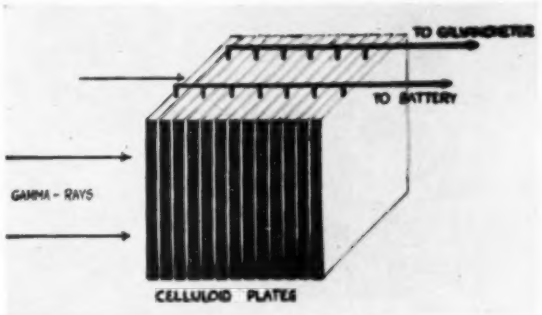

Fig. 6. Principle of method of measuring total gamma-ray energy absorbed in a block of tissues by measuring the ionization current in the air gaps of a laminated celluloid model.

(Fig. 7) it is possible to measure directly with a galvanometer the total body absorption under various conditions of treatment. For example, the variation in the total body absorption with different settings of the gamma-ray beam, and with different nozzles on the unit, can be measured very simply and quickly. Also the protection afforded to a patient's body by various types of radium units can be studied directly.

The method is applicable to roentgen and gamma-ray therapy, and may perhaps also prove useful for estimating the body absorption of persons working with strong neutron beams.

V. Comparison of Biological Effects of Hard and Soft Gamma Rays

Some experiments have been made, in cooperation with Dr. F. G. Spear of the Strangeways Laboratory, Cambridge, to compare biological effects of hard and soft gamma radiation. Tissue cultures of chick embryo were exposed to the gamma rays from 5 gm. of radium (Fig. 8). The quality

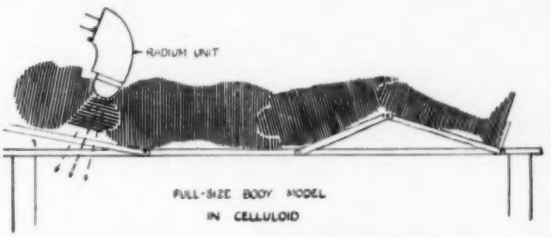

Fig. 7. Method of estimating total absorption of energy by whole body during treatment by means of a full-sized model built up of celluloid sheets.

of the radiation could be changed by inserting lead filters of different thicknesses up to 2.6 cm.

The time of exposure was twenty minutes in each case. The dosage rate, as measured by a small thick-walled Sievert condenser chamber, was arranged to be the same whatever the filtration, by varying the distance of the culture from the radium.

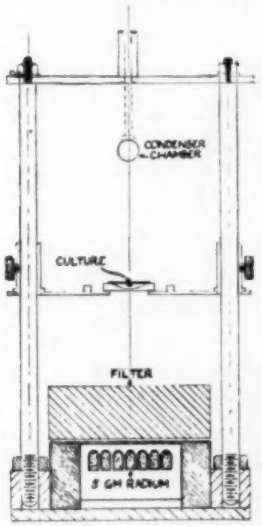

Fig. 8. Apparatus for exposing tissue cultures to measured doses of gamma rays from 5 gm. of radium. The quality of the rays can be changed by inserting lead filters up to 2.6 cm. thick.

The biological response was measured by comparing the number of dividing cells seen in a culture after irradiation and eighty minutes' subsequent incubation,

with the number of dividing cells in the unexposed controls. Table II shows the mitotic survival for equal does of gamma rays of three different qualities, corresponding to filters of 0, 0.93 cm. lead and 2.62 cm. lead.

TABLE II

EFFECTS OF EQUAL DOSES OF GAMMA RAYS OF DIFFERENT QUALITIES ON MITOSIS IN CULTURES OF CHICK EMBRYO

Dose: 130 r Time of exposure: 20 minutes (Initial Filtration 0.35 mm. Au+0.30 mm. Pt+1 mm. brass)

Filter	Mitotic Survival
0	43 per cent 42 per cent
0.93 cm. Pb	51 per cent 53 per cent
2.62 cm. Pb	67 per cent 68 per cent

It will be seen that the mitotic survival is greatest in the case of the hard gamma rays, or in other words, a mixture of hard and soft gamma rays is much more effective in arresting cell division in these cultures than hard gamma rays, for equal energy absorption.

Grateful acknowledgment is made to the Governing Body of the Radium Beam Therapy Research, to the Radium Institute, the Medical Research Council, the Department of Scientific and Industrial Research, the Royal College of Physicians, the Royal College of Surgeons (Prophit Trust), the Union Miniere du Haut Katanga, the British Empire Cancer Campaign, the Graves' Charitable Trust, and Mr. Harry Oakes.

REFERENCES

1. GRIMMETT, L. G. Five-gramme radium unit, with pneumatic transference of radium. *Brit. J. Radiol.*, 1937, *10*, 105–117.
2. MCLENNAN, J. C., and SMITHELLS, C. J. *J. Sci. Inst.*, 1935, *12*, 159.
3. GRIMMETT, L. G., and READ, J. Application of new dense tungsten alloy in teleradium therapy. *Brit. J. Radiol.*, 1935, *8*, 661–665.
4. SMITHELLS, C. J. *Nature*, 1937, *139*, 490.
5. WOOD, C. A. P., and GREEN, T. A. Delivery, estimation and control of tissue dosage in radiation therapy. *Brit. J. Radiol.*, 1937, *10*, 73–93.
6. GREEN, T. A. Directional caliper; its clinical uses in radiation therapy. *Brit. J. Radiol.*, 1937, *10*, 95–101.

Vol. 41, No. 3

LOW VOLTAGE ROENTGEN THERAPY IN SKIN CANCER

A STUDY ON RELATIONSHIP OF DOSAGE TO SIZE OF FIELD*

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LOW voltage roentgen therapy is one of several generally approved methods for the treatment of cancer of the skin. The results obtained by other methods may be equally as good, but there are certain advantages in the use of low voltage roentgen rays. In the treatment of skin cancers about the face the cosmetic result has been found to be better with this type of therapy than by any other method. When the lesion is located near the eyes, the problem of shielding is of great importance. If radium is employed, complete protection to the eyes cannot be obtained because of the amount of lead required for the absorption of an appreciable part of the radiation. Late degenerative changes of the lens in the form of cataract are noted with increasing frequency in those patients who were treated by radium some time ago for skin cancer near the eyes. The low voltage roentgen rays, because of their high absorption coefficient in lead, are to be recommended in the treatment of skin cancers in such areas. This, of course, does not apply to deeply infiltrating lesions or to adenoid cystic basal cell epitheliomas where invasion of bone is frequently also found.

Radiation dosage is commonly expressed in terms of roentgens measured in air. It is inadequate to state that a lesion was controlled by low voltage radiation by means of a certain number of roentgens, unless all other physical factors have been given. Since it is generally known that a greater number of roentgens is necessary to obtain an erythema from soft than from hard radiation, it is necessary to relate the therapeutic dose to some biologic unit. The threshold erythema is the means commonly employed for this purpose. The threshold erythema dose, as used at Memorial Hospital, has been defined as that quantity of radiation which produces in 80 per cent of all patients treated, a visible pigmentation within one month, and in the others no visible reaction.

In reviewing the literature on low voltage roentgen rays one finds that the values given by various observers for the erythema dose vary anywhere from 300 to 700 r. In many instances neither the specific quality of radiation, the size of the field nor the part of the body used in the test have been mentioned. Since the present report is concerned with reactions on small fields, only data referring to such areas need be mentioned. Only two reports have been found in the literature which give well defined data of this type.

Reisner,[1] in a comprehensive report, found that 450 r gave an erythema for 75 kv. (half-value layer, 0.4 mm. Al) for a 2×2 cm. field. MacKee and Cipollaro[2] on 61 subjects used areas of skin 2.5 cm. sq., one to six areas per person. These fields were on the flexor surface of the forearm, the inner surface of the thigh and the lumbar region. Unfiltered radiation, 80 to 100 kv. was used and 64 to 485 r (measured in air) was applied. With thermionic rectification all persons tested with 212 r showed an erythema within a week or ten days which persisted for about two weeks. When a mechanical rectifying machine was used, an erythema was observed at 266 r in the majority of cases.

Reisner[1] has emphasized the point that in making erythema determinations it is unwise to compare those made on skin un-

* From the Head and Neck Department. Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

accustomed to light with those on skin usually exposed to light. The anterior surface of the thigh is undoubtedly the best skin surface for making these tests. Quimby and Copeland[3] found that it required about 25 per cent less radiation (200 kv.) to produce a threshold reaction on a 4×4 cm. field on the thigh than on a corresponding area on the forearm. Certainly no tests should be made on parts of the body which will be subjected to pressure from sitting or lying in bed. The presence of an erythema is sometimes difficult to determine if there is a heavy growth of hair. It is to be noted that when looking for a faint erythema or pigmentation, the patient should be in a good light but not in direct sunlight. Readings should be made at about the same hour of the day and should not be attempted on dark, cloudy days.

Low voltage radiation for skin cancer has developed more or less on an empiric basis, each clinic for the most part having evolved its own technique. This is true of our own, where it has been customary to attempt to give an adequate amount of radiation at one sitting. In a busy therapy department this is important, because a certain amount of time is necessary in carefully setting up the patient for treatment. To repeat a treatment one or more times on many patients greatly increases the work of the department. For this reason the original idea of attempting to give a single dose of radiation sufficient to control the lesion has been continued. In the beginning we employed for this purpose, unfiltered low voltage roentgen rays generated at 140 kv. Doses of 2,000 and 3,000 r were found to be inadequate for fields less than 3 cm. in diameter. After it had been determined that larger doses could be given with no ill effects, a softer radiation was employed. This was obtained from roentgen rays generated at 100 kv., and it was then found that still larger doses were necessary. The results were then more satisfactory, for there were fewer instances of incomplete regression or of recurrence.

The size of the field is one of the most important factors in the treatment of skin cancers by means of low voltage radiation. Fields varying from 0.5 to 5 cm. in diameter are most commonly used about the face. Therefore, we have attempted to determine the threshold erythema dose for a series of fields within this range when the radiation is administered at one sitting. Twelve male patients from the Head and Neck Service of the Memorial Hospital have been used, utilizing the anterior and lateral surfaces of the thighs, ten fields to each patient. The roentgen rays used were generated at 100 kv. and 5 ma., giving an intensity of 270 r per minute at 30 cm. target-skin distance without filter. The half-value layer of the radiation was 0.03 mm. Cu or 1 mm. Al. One field of each of the above sizes was irradiated on each thigh of every individual. Areas of the proper size were obtained by cutting the desired circular openings in a sheet of lead one-eighth inch in thickness. A layer of celluloid 1 mm. thick was placed beneath the lead in contact with the skin to absorb the secondary radiation of the lead.

For those fields with diameters of 0.5 cm., 1 cm. and 2 cm., 350 r gave an erythema in 80 per cent of the cases. For the fields of 3 and 4.5 cm. in diameter, 280 r gave an erythema. In evaluating the results it has been found impossible to determine a different value for each field, the margin being too narrow for such small fields. This is to be expected since it is impossible to determine the erythema dose to better than 10 per cent. This is demonstrated in the first table.

Table I

SKIN DOSE IN PERCENTAGE OF PRIMARY BEAM AS 100 PER CENT: 100 KV.; HALF-VALUE LAYER, 1 MM. AL

Diameter of Field cm.	Area of Field	Skin Dose Per Cent	Erythema in Roentgens
0.5	0.2 sq. cm.	101	350 r
1.0	0.8 sq. cm.	102	350 r
2.0	3.0 sq. cm.	104	350 r
3.0	7.0 sq. cm.	108	280 r
4.5	16.0 sq. cm.	113	280 r

Accurate physical measurements show that among the three smallest fields, the skin dose delivered by a given number of roentgens measured in air varies by only 5 per cent. The same is true for the two largest, but between the average of the smaller group and the larger group a difference of about 10 per cent exists.

In an attempt to correlate the clinical with experimental data, results have been analyzed on a group of 50 patients treated in the Head and Neck Clinic at Memorial Hospital for carcinoma of the skin of the face by means of unfiltered low voltage roentgen rays.

In 4 instances the microscopical report was squamous cell carcinoma and in the remainder it was basal cell epithelioma. When the thickness of the lesion exceeded 3 to 4 mm., the external portion was removed by actual cautery before the radiation was given, reducing the level of the lesion to that of the skin surface. At the time of irradiation the normal skin surrounding the lesion was protected by means of lead foil, 0.5 mm. in thickness in the following manner: The outlines of the lesion were traced upon transparent paper by means of an indelible pencil. An area 4 to 5 mm. in width was added on all sides to this diagram and its counterpart cut from the lead foil. Thus, the lesion and an area surrounding it, 0.5 cm. in width, were irradiated. In this group of patients the diameters of the fields varied from 1 to 6 cm.; 6,500 r was the largest dose administered which was on a field 1.5 cm. in diameter. The smallest dose of 1,200 r was given on a field 2.5 cm. in diameter. From the time when 100 kv. was first employed, larger doses were given than when 140 kv. had been used. Therefore, for the most part, adequate doses were being administered at the time this group of patients was treated. Consequently in this series of 50 patients only 6 have been found in which the dose was insufficient. Incomplete healing was not noted in any patient.

On the basis of the doses delivered to the group of 44 patients treated successfully, it is possible to determine the number of threshold erythema doses which produced these results. It was found that in no case

Table II

DATA ON SERIES OF FIFTY PATIENTS

Diameter of Field	Number of Patients	Dosage Range
Group Showing Complete Regression		
1.0 cm.	1	5000 r
1.0 cm.	2	6000 r
1.5 cm. (S)	1	4500 r
1.5 cm.	6	5000 r
1.5 cm.	3	6000 r
1.5 cm.	2	6500 r
2.0 cm.	1	4000 r
2.0 cm.	2	4500 r
2.0 cm.	2	5000 r
2.0 cm.	2	6000 r
2.5 cm.	1	3000 r
2.5 cm. (S)	2	4500 r
2.5 cm.	5	5000 r
3.0 cm.	1	4000 r
3.0 cm. (S)	2	5000 r
3.5 cm.	1	3500 r
3.5 cm.	1	4000 r
4.0 cm.	1	4000 r
4.0 cm.	1	4500 r
4.5 cm.	1	4000 r
4.5 cm.	1	6000 r
5.0 cm.	1	4000 r
5.0 cm.	1	3500 r
5.5 cm.	1	3500 r
6.0 cm.	1	4000 r
6.0 cm.	1	3000 r
Group Showing Incomplete Regression		
1.5 cm.	1	4500 r
2.0 cm.	1	5000 r
2.5 cm.	1	1200 r
3.5 cm.	1	4500 r
5.5 cm.	1	3500 r
6.0 cm. (S)	1	2150 r

(S) Squamous carcinoma.

did satisfactory regression occur with less than 12½ T.E.D. However, there are not enough patients showing incomplete regression to warrant a statement of a dose below which regression may not be expected. In 3 of the 6 patients showing incomplete regression, the doses should have been sufficient when the diameters of the fields are compared with those of the favorable group.

TABLE III

DOSES CONSIDERED AS SUFFICIENT FOR FIELDS OF VARYING SIZES

Diameter of Area	Doses in Roentgens	Erythema	Dose in Threshold Erythema
0.5 cm.	6500 r	350 r	18½
1.0 cm.	6000 r	350 r	17
2.0 cm.	5000 r	350 r	14
3.0 cm.	4500 r	280 r	16
4.0 cm.	4000 r	280 r	14
5.0 cm.	3500 r	280 r	12½

It is possible that in these cases a greater degree of infiltration might account for the incomplete regression of the disease.

From the data obtained in the group of patients in whom the results were satisfactory, a table has been made in which are given doses believed to be sufficient for lesions of various diameters (Table III).

In this table are given the doses in roentgens which have been found to be adequate for fields ranging in diameter from 0.5 to 5 cm. They have also been stated in threshold erythema doses calculated from the experimental data. Whereas on a basis of physical measurements it would appear that about 15 per cent more radiation could be given to a field 0.5 cm. in diameter than to one 5 cm. in diameter, clinically the difference is much greater and actually it is found to be nearly twice as much. That is, where 3,500 r were found to be sufficient for complete regression of disease in a lesion 5 cm. in diameter, 6,500 r were necessary for one 0.5 cm. in diameter.*

SUMMARY

The threshold erythema dose has been determined experimentally for unfiltered low voltage radiation for small circular fields. A group of fifty patients treated for skin carcinoma of the face has been followed for a sufficient period of time to permit conclusions to be drawn. From the group in whom regression was complete, the doses in roentgens for the various size fields have been tabulated. These have also been expressed in terms of the threshold erythema doses determined experimentally.

REFERENCES

1. Reisner, A. Hauterythem und Röntgenstrahlung. *Ergebn. d. med. Strahlenforsch.*, 1933, *6*, 1–60.
2. MacKee, G. M., and Cipollaro, A. C. Roentgen unit in dermatology. *Arch. Dermat. & Syph.*, 1934, *30*, 761–771.
3. Quimby, E. H., and Copeland, M. M. Personal communication.

* During the eighteen months which have elapsed since the presentation of this material before the Fifth International Congress of Radiology, increasingly larger doses have been employed, especially to the smaller fields of 1 cm. or less. As much as 9,000 and 10,000 r have been administered. In no instance has there been delayed or incomplete healing.

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THE BIOLOGICAL MEASUREMENT OF RADIATIONS*

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THE measurement of radiations by means of some biological method is a logical procedure. If we wish to produce in the living organism some change, such as a retardation in the rate of cell division or the destruction of malignant tissues, it is natural to test the effectiveness of the rays by means of a biological indicator. The early radiologists appreciated this fact and therefore used as test objects various kinds of seeds and eggs, and the human skin. Among the pioneers in this type of research were Ritter, Krönig and Friedrich, and Jüngling. Ritter was the first to attempt to correlate the physical dose, determined by the pastille method, with the amount of biological effect produced in growing seedlings. Jüngling tried to measure roentgen-ray intensities in a water phantom by the same method. These investigators realized that their methods were not wholly satisfactory; the results were highly variable and showed only the order of magnitude of the doses. And since the biological experiments were time consuming, they were practically abandoned.

In the meantime, physical methods of measurement were greatly improved. With the adoption of the roentgen and the development of the thimble chamber dosimeter, it was hoped that dosage problems could be quickly solved. But the hope has not yet been fulfilled. As evidence of this, one needs only to read the titles of papers presented at this Congress on the subject of roentgen-ray and gamma-ray measurement. Even the adequacy of the roentgen is questioned. A review of the extensive literature of the past ten years shows how difficult it is to come to an agreement on what appear to be simple problems of measurement. The amount of back-scattered radiation found by different observers varies by as much as 100 per cent, even when the physical conditions are approximately similar. It is now realized that scattering media, such as rice and paraffin, may show the same absorbing and scattering properties as water at certain voltages but not at others. A source of error, unsuspected until recently, is found in the size of the thimble chamber. Those of large dimensions record higher depth intensities than those of small diameter, especially in the region close to the surface. These, and other still unsettled questions show how difficult it is to measure dosage by physical means. And should these problems be solved, the more complicated matter of the relation between dose and biological effect would still remain. We are now finding out that biological test objects do not always respond alike to equal doses, measured in roentgens.

The chief criticism of the biological method of measurement has been that it is not precise; that the results of tests repeated under apparently similar experimental conditions vary so much among themselves that the averaged result is not significant. Indeed, Bolaffio, who experimented with seedlings, remarked some years ago that the results represent not a measure but a preference. But the improved methods now in use demonstrate that this criticism is no longer valid. As an example of the degree of precision which may be obtained in experiments with the fruit fly, *Drosophila*, the data in Table 1 are presented. When these eggs are given ionization doses, measured without scatter, a definite proportion are killed, the remainder surviving and developing into normal adults. The amount of variation found in repeated tests is illustrated in the data. In each series there are 15 separate tests, made during the past seven years. A comparison of the individual

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13-17, 1937.

results with the average shows how great is the consistency of response. The average deviation of a single test is 2.6 per cent; the probable errors of the means indicate that should these series be enlarged so as to include a great number of similar tests, the average of such series would differ from those shown in the table by less than 2 per cent. A simple analysis of this kind should be made of the results obtained with each type of biological test object which is used.

TABLE I
PER CENT SURVIVAL

	Dose 117 r	Dose 200 r	Dose 245 r
	75.8	41.5	29.0
	76.2	41.7	29.9
	77.1	42.4	30.8
	78.0	43.1	30.9
	78.2	44.3	31.3
	78.3	45.2	31.6
	78.5	45.7	31.7
	79.0	46.4	32.1
	79.1	46.6	32.4
	79.2	47.0	33.1
	79.4	47.4	36.3
	79.8	48.0	36.5
	80.1	48.4	37.2
	81.2	48.8	37.9
	84.4	48.9	38.3
Average	79.0	45.7	33.3
Probable errors of the means	0.35	0.43	0.52
Biological r	118	203	244

When these and similar series obtained with larger and smaller doses are plotted appropriately, the percentage survivals fall along a straight line. Thus the expected survival rate which will follow a dose of any magnitude, within certain limits, can be found. Similarly, the actual percentages obtained in such a series show, with the same degree of precision, the number of roentgens which the eggs received. That this is true can be inferred from the figures marked "biological r" at the bottom of the table. These are obtained by finding on the curve, the number of roentgens corresponding to the average survival rate of each series. The agreement between the doses determined by this biological method and by the dosimeter is satisfactory. These results have been obtained from several strains of wild fruit flies over a period of some years. No further proof of the constancy of response of this biological material is needed.

There are some radiological problems which can be solved only by the use of the biological method of measurement; of these the most important is that of the effectiveness of different wave lengths. The long-standing lack of agreement on this topic was due not only to the early inaccuracies in physical and biological measurement, but also to the fact already mentioned, that equal doses do not always produce equal quantitative results. This is due, not to a difference in the action of the rays, but rather to certain biological factors which are only now beginning to be understood.

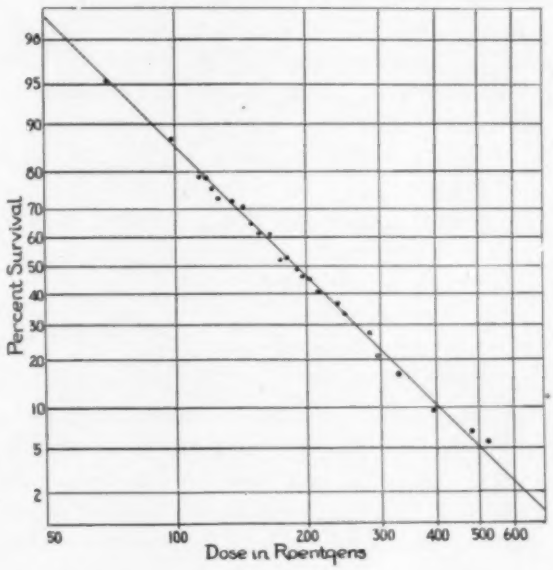

FIG. 1

The first large experiment on this problem was made by Wood who avoided errors which others had fallen into. Using appropriate target materials and filters, he obtained homogeneous beams of three different wave lengths. Their intensity was measured with an open ionization chamber. Mouse tumor tissue served as a test object. After irradiation this was inoculated into

thousands of healthy animals. The results showed that the number of takes was the same when equal doses of the three qualities of radiation were given. Subsequently experiments with *Drosophila* eggs, treated under the same physical conditions as the tumor tissue, confirmed the earlier results. Further tests with these eggs have shown that their reaction is independent of the wave length over a very wide range, the extremes being 1.6 Å. generated at 12 kv. and 0.05 Å. produced at 550 kv. Henshaw finds that beams of 200 and 700 kv. are equally effective on seedlings. The literature demonstrating the truth of this general principle is now extensive.

The biological method of measurement can also be used to determine surface and depth doses. The procedure is to place the eggs in a suitable container at different levels in a water phantom, and to determine, by their survival rate, the number of roentgens which they must have received in each position. The results of tests, repeated during several years, have shown that under the conditions used, the intensities below the surface are significantly greater than those obtained by dosimetric means. The differences between the results of biological and physical measurements are most apparent in the first few centimeters below the surface under large portals. Under small portals and at depths of 5 cm. or more, the differences largely disappear. It is probable that the eggs, which respond equally to very soft and to hard radiations, are affected by the softest scattered rays which the ordinary dosimeters do not register correctly.

The present physical methods of measuring roentgen-ray beams in air are satisfactory within the range of wave lengths ordinarily used in therapy. For determining the intensity of gamma rays and high voltage roentgen rays other forms of dosimeters must be used. Whether the air wall thimble chambers furnish correct values of gamma radiation is still debated. Under standard conditions of filtration and distance, the dosimeter method shows that the output from 1 millicurie of radon per hour is about 8 roentgens. A biological measurement of these rays, made under similar physical conditions, indicates an output of 5 roentgens per millicurie-hour. This has been demonstrated independently by two observers. Whether this difference is due to difficulties inherent in the physical method, or to the fact that gamma rays may be biologically less effective than roentgen rays produced at ordinary voltages cannot now be decided. But whatever may be the reason, the value found by the biological method is of practical importance, since it indicates with reasonable precision the biological activity of gamma rays in terms of roentgens.

For measuring the intensity of roentgen rays produced at voltages of 400 kv. and upwards, the biological method has proved useful. While it is not possible to specify doses in standard roentgens, it can be said that under definite conditions of voltage, filtration and distance, a certain exposure produces the same quantitative effect on the eggs as a definite number of roentgens of x-rays generated at ordinary voltages. In these tests the beams have also been measured with a Victoreen dosimeter. The results of the two methods of measurement do not agree, especially in the region of the highest voltages. This is to be expected, for the dosimeter is not constructed to record accurately doses of very short wave lengths. A comparison of the results shows that when the potential is 200 kv. doses measured by means of the fly eggs agree with the dosimeter readings; at 600 kv. the biological dose is about 83 per cent, and at 900 kv. about 81 per cent of the dosimeter dose. By introducing appropriate corrections for each voltage, the dosimeter can be used in making routine measurements.

The biological method of measurement is logical, it is accurate, and it can be put to practical use.

RECENT METALIX TUBE DEVELOPMENTS*

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EINDHOVEN, HOLLAND

THE "Metalix" tubes already known were characterized by the fact that the glass bulb was replaced by a metal center part. The division of the whole tension on the tube into two equal parts thus obtained, provided a more favorable electrical field along the glass, and shorter tubes could be built. Moreover, it was in this way possible to fit the lead for the roentgen-ray protection next to the tube. The metal chamber, which was formed by the center part and the other electrodes, had a good effect on the stability and life of the tube, as glass charges and liberation of gas were reduced.

These principles, which justified themselves in practice were also applied to the newly developed tubes. The application of "getters" with large gas-absorbing capacity has also contributed to a successful development. These "getters" have also improved the quality of the already existing types of tubes.

The following new tubes were developed similar to those used in radio valves:

(*a*) *Self-shielding Diagnostic Tube* (Fig. 1). By the special simple construction of this tube it was possible to obtain complete electrical protection without the application of a separate shield, as the tube consists of a metal center part on which sockets of "Philite" (an artificial resin) are attached to each end. To these sockets the cable ends are connected, which are metalized on the outside. This metallization is connected with the center part and all is grounded. For insulation only solid insulators with a high electrical strength are

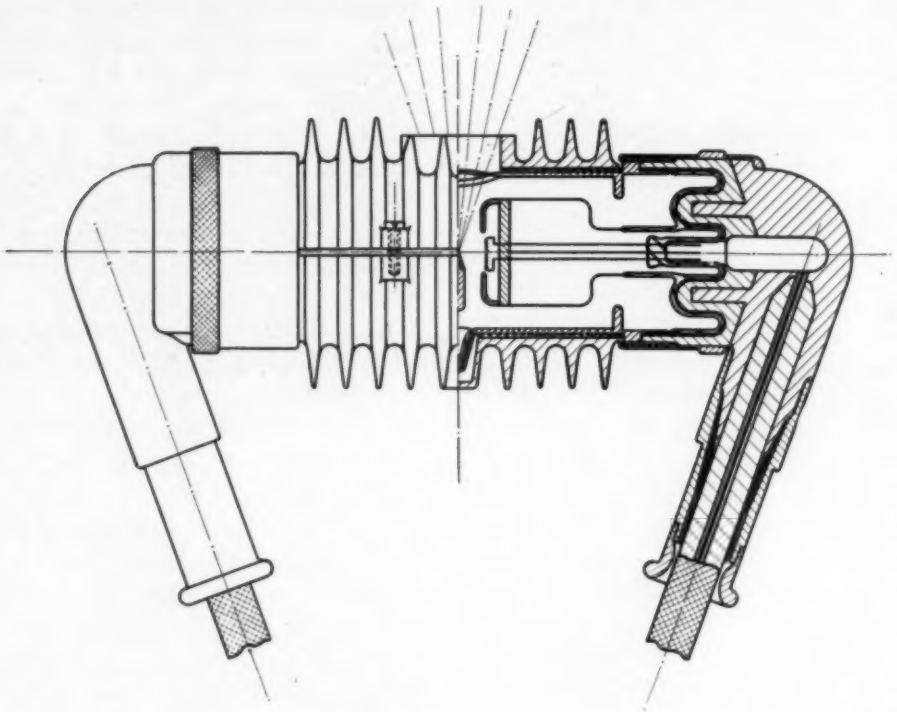

FIG. 1

* From the X-Ray Research Laboratories, N. V. Philips' Gloeilampenfabrieken, Eindhoven, Holland. Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

used. Thus it was possible to reduce the glass length between the center part and the electrodes to a minimum.

The heat developed in the anode is dissipated to the center part by radiation; the center part is provided with a radiator, the latter being cooled by air convection. Oil- or watercooling is superfluous, even for high continuous loads up to about 120 watts.

The anode is provided with a large surface and is artificially blackened, as has been done before for "Rotalix" tubes.[1] Besides, the anode has a large volume and consequently a large heat capacity. By these properties the anode temperature is kept below 500° C., thus permitting the same roentgen output as for normal diagnostic tubes hitherto used.

The primary radiation is filtered only by the thin glass window in the center part, so that there is no loss of radiation by this window.

(*b*) "*Rotalix*" *Tubes*. These tubes, which are nowadays used in almost every hospital in Europe are much improved. The electrical margin of safety, which is of special importance for the use of the tubes on unknown apparatus in frequently unforeseen circumstances, has been increased.

By a better anode construction and the employment of more resistant materials, it was possible to admit a higher specific load of the focal spot.

A new shield of smaller dimensions and weight was developed (Fig. 2). In this shield as well as in the older ones "Rotalix" tubes with double focus are now available.

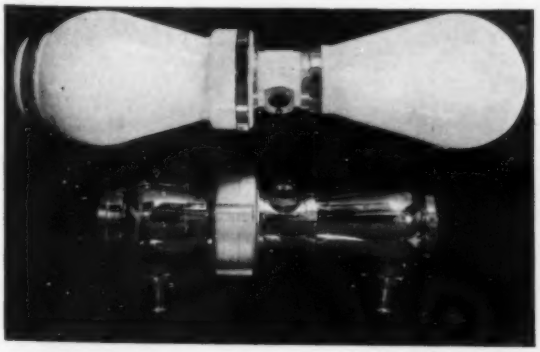

Fig. 2

Fig. 3

An entirely new bearing system is developed.

(*c*) "*Centralix*" *Apparatus*. This type of apparatus was described by one of us (A.B.) at the American Congress of Radiology in Chicago, 1933.[2]

A small apparatus for dental use has now been constructed according to the same principles. Owing to the very fine focal spot it produces very sharp roentgenograms. Experience has shown that these roentgenograms are of even better quality than those made with the usual and much larger apparatus. They may be made to be held in the hand, as the weight is only 3 kg., or used with a very simple suspension, as for example shown in Figure 3.

Of course the tube of this apparatus is also provided with a metal center part; the length is only $3\frac{1}{2}$ inches and the overall diameter $\frac{3}{4}$ inch.

By the application of the earthed metal center part there is no extra filtering of the

primary radiation, which is otherwise hardly to avoid.

(*d*) *A Sealed-off Supervoltage Therapy Tube for One Million Volts.* The principal progress in the therapy field was the development of a tube for one million volts, which will be described in detail by one of us[3] (A.B.) during this Congress. The principle has already been published for a 700 kv. tube by Bouwers and van der Tuuk.[4]

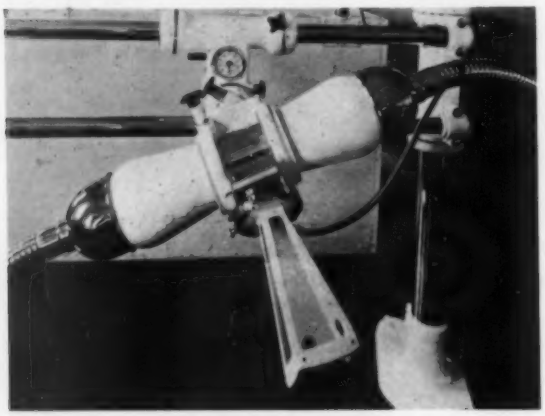

FIG. 5

The tube for one million volts is built on the cascade principle and consists of three sections connected in series (Fig. 4), which are exhausted separately. The sections are also tested separately at 400 kv. each and soldered together afterwards.

Several "getters" maintain an excellent vacuum during the further working of the tube.

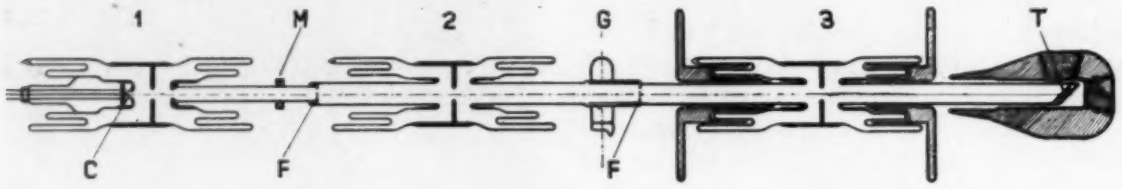

FIG. 4

By this cascade construction a completely homogeneous subdivision of the tension is obtained; moreover, only the primary focused electrons are able to reach the anode and these are the only particles in the tube which can obtain an energy corresponding with the total tension.

(*e*) *Therapy Tubes for Tensions up to 220 kv.* (Figs. 5 and 6). By a consistent application of solid insulators it was possible to realize a small therapy shield.

The center part of the tube is grounded and the tube revolves in the shield by means of a clamp which is attached to the center part. When the tube is turned around its axis, the cables do not revolve.

In this shield a tube may be used for currents up to 20 ma. with water-cooling, the water passing through the center of the high voltage cable. Also a tube with radiating anode may be used in a similar shield.

In the latter case the anode is cooled as described for the self-shielding diagnostic tube. The continuous load in therapy is much higher than in diagnosis and therefore a cooling of the center part is neces-

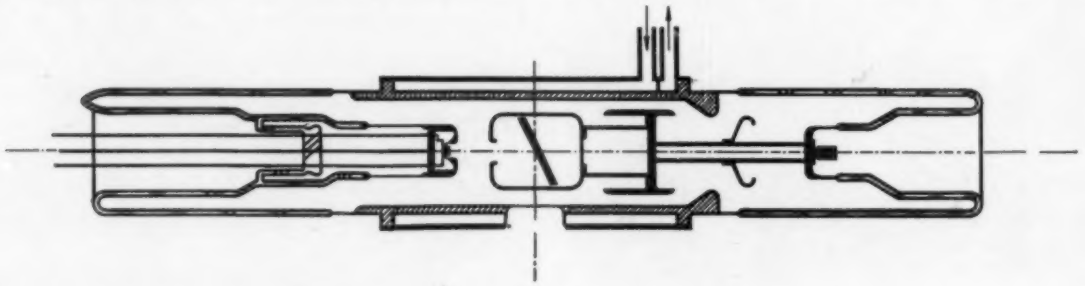

FIG. 6

sary. As this center part is grounded, the cooling water can be tapped from the mains and an insulated pump is no longer necessary.

By a special anode construction and cooling system a high continuously permissible load of the focal spot is obtained. For a focal spot of 1.2 mm. square 25 ma. at 50 kv.

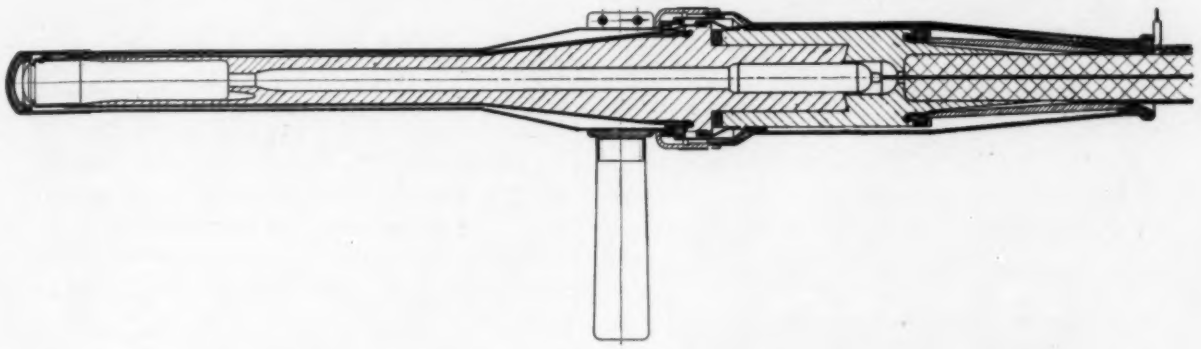

Fig. 7

(*f*) *Tube for Cavity Therapy* (Fig. 7). This tube has already been described by van der Tuuk and van der Plaats.[5,6] The most important features are the small overall diameter of 1⅛ inches and the very low (peak) is allowed. The anode is grounded and may be cooled from the water mains.

The shield has small dimensions and permits a quick change of the tube, if a different anode material is desired.

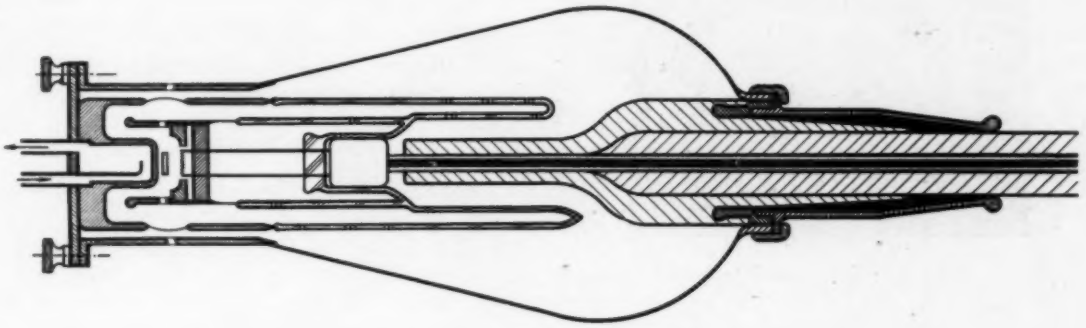

Fig. 8

fixed filter, owing to which a large surface dose may be obtained. The anode dissipates its energy by radiation to the metal part in which the cathode is fixed. This metal part is cooled by a blower.

As the tube has a small weight and the cable is very flexible, the fixing causes no difficulties and it is easy to perform radiations from free hand.

(*g*) *Metalix Tube for Crystal Analysis.* Though this tube, which is described in detail elsewhere,[7] in the first place was not meant for medical purposes, we will include it, for the sake of completeness. Figure 8 gives a diagram of this tube in its shield.

REFERENCES

1. Bouwers, A. Eine Röntgenröhre mit drehbarer Anode und "Anodenkühlung." *Fortschr. a d. Geb. d. Röntgenstrahlen*, 1933, *48*, 232–233.
2. Bouwers, A. Some new principles in design of x-ray apparatus. *Radiology*, 1934, *22*, 163–173.
3. Bouwers, A. Paper read at the Fifth International Congress of Radiology, Chicago, 1937.
4. Bouwers, A., and van der Tuuk, J. H. New x-ray tube for 700 k.v. and some measurements of penetrating radiation. *Brit. J. Radiol.*, 1936, *9*, 431–441.
5. van der Tuuk, J. H., and van der Plaats, G. J. *Nederl. tijdschr. v. geneesk.*, 1935, *79*, 4025.
6. van der Tuuk, J. H. *Nederl. tijdschr. v. natuurk.*, 1936, *3*, 129.
7. de Graaf, J. E., and Oosterkamp, W. J. *J. Sci. Instruments*, 1938, *15*, 293.

THE EFFECTS OF ROENTGEN RADIATION AND PROLAN UPON THE TESTES OF IMMATURE RATS

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A DIFFERENCE in susceptibility to roentgen rays, somewhat comparable to that existing between certain neoplasms and the surrounding normal tissue, has been found in the rat testis where 1,000 roentgens almost completely destroys the seminiferous epithelium but leaves the Leydig tissue intact. Bourg† found that such a dosage of roentgen radiation given to immature rats not only left the Leydig cells capable of proliferating in response to the gonad-stimulating hormone of pregnant women's urine (prolan) but also capable of secreting the male sex hormone as determined by prostatic growth.

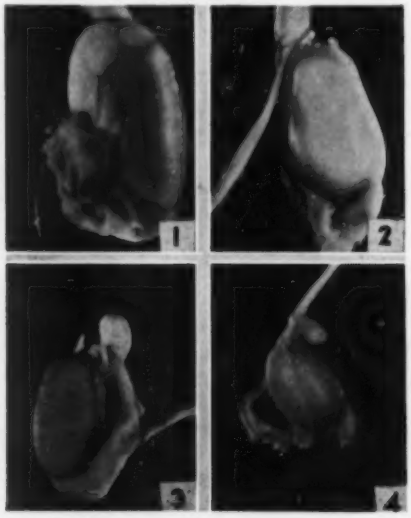

FIG. 1 (×2). Testis of thirty-three-day-old untreated rat W-02.
FIG. 2 (×2). Testis of rat BH-74. Half of testis received 4,608 r. Note shrinkage due to roentgen irradiation in upper part of figure. See Figures 9 and 10 for histology of this testis.
FIG. 3 (×2). Testis of rat W-29. Whole testis received 1,152 r; 35 units of prolan injected. See Figure 11 for histology.
FIG. 4 (×2). Testis of rat BH-75. Whole testis received 4,608 r. No prolan; histology same as Figure 12.

Before learning of Bourg's work, somewhat similar experiments had been carried out by us in a preliminary investigation of a roentgen-ray bio-assay method that might possibly be satisfactory from both functional and morphological aspects. Where the technique used closely paralleled that of Bourg our findings were identical. This report is made, therefore, in confirmation of Bourg's work and because of slight differences in our procedure.

EXPERIMENTAL PROCEDURE

Twenty-one-day-old male rats of the Long-Evans strain were used. Under sodium amytal anesthesia the left testis and epididymis were removed, and the right gonad was drawn through a small opening in the belly wall, and carefully wrapped in gauze dampened with sterile saline. The whole testis of certain animals was irradiated directly, care being taken to shield the rest of the animal with lead. In some rats only half of the testis was exposed to roentgen radiation, while in others no roentgen treatment was given but the testis was exposed for fifteen minutes and handled as in the irradiated animals. Three rats were completely castrated.

The irradiation was done with a General Electric Snook machine with a Coolidge Universal broad focus tube. When operating at 120 kv. and 10 ma. at a 25 cm. target-testis distance in air without a filter, 384 r was delivered per minute as checked by the Victoreen ionization dosimeter. Some of the animals received 1,152 r, and some 4,608 r. The testes were replaced, and after an interval of seven

* Deceased.

† Bourg, R. Recherches sur l'histophysiologie de l'ovaire, du testicule et des tractus génitaux du rat et de la souris. *Arch. de biol.* 1931, *41*, 245–341.

TABLE I

Group	Rat	Roentgen Radiation	Prolan	Body Weight at Necropsy gm.	Weight of Testis and Epididymis mg.	Weight of Seminal Vesicles and Prostate mg.
1	W-02	—	—	86	264	77
	W-03	—	—	80	222	62
	W-04	—	—	85	255	69
2	W-05	—	—	72	—	52
	W-06	—	—	79	—	49
	BH-01	—	—	84	—	54
3	W-28	½ testis, 1152 r	—	72	128	43
	GH-12	½ testis, 4608 r	—	67	126	37
	W-46	1 testis, 1152 r	—	81	82	45
	BH-75	1 testis, 4608 r	—	85	51	36
4	BH-16	—	35 units	70	244	103
	B-51	—	35 units	78	227	98
	B-89	—	35 units	83	269	100
5	W-21	½ testis, 1152 r	35 units	88	179	118
	W-31	½ testis, 1152 r	35 units	75	117	103
	BH-96	½ testis, 4608 r	35 units	94	181	96
	BH-74	½ testis, 4608 r	35 units	88	141	96
6	W-73	1 testis, 1152 r	35 units	88	97	57
	W-29	1 testis, 1152 r	35 units	76	79	75
	BH-91	1 testis, 4608 r	35 units	64	51	54
	BH-85	1 testis, 4608 r	35 units	82	60	83

Group 1, unoperated; Group 2, both testes removed; Groups 3, 4, 5 and 6, 1 testis removed. All rats were thirty-three days old at necropsy.

days some of the irradiated and non-irradiated rats received daily subcutaneous injections of 7 units of prolan* for five days. Twenty-four hours after the last injection the rats were weighed, and at necropsy the reproductive organs were removed and fixed. After partial dehydration in alcohol the testes, prostates and seminal vesicles were weighed, and the testes and prostates then imbedded in celloidin, sectioned and stained with hematoxylin and eosin. All tissues were handled simultaneously and treated alike.

* A purified preparation of the gonad-stimulating substance of pregnant women's urine was used. A unit is represented by the smallest amount necessary to stimulate the growth of follicles and "luteinization" in twenty-one-day-old female fats. In male rats prolan causes a mitotic proliferation of the Leydig cells, attended by a rapidly growing vascular network. Whether this vascular stimulus could be expected to offset a roentgen angiitis is not known.

RESULTS

Because complete castration of twenty-one-day-old rats was followed by a decrease in the combined weights of the prostate and seminal vesicles (Group 2, Table 1), it would seem that at this age the testis may already be secreting some male sex hormone.

Both dosages of roentgen radiation (1,152 and 4,608 r) whether given to the whole or half of the remaining testis in unilateral castrates caused a marked decrease in testicular size and weight (Groups 3, 5, 6), (Figs. 2–4). The irradiated testes showed a marked atrophy of the seminiferous tubules with degeneration of all but a single layer of cells, most of which were

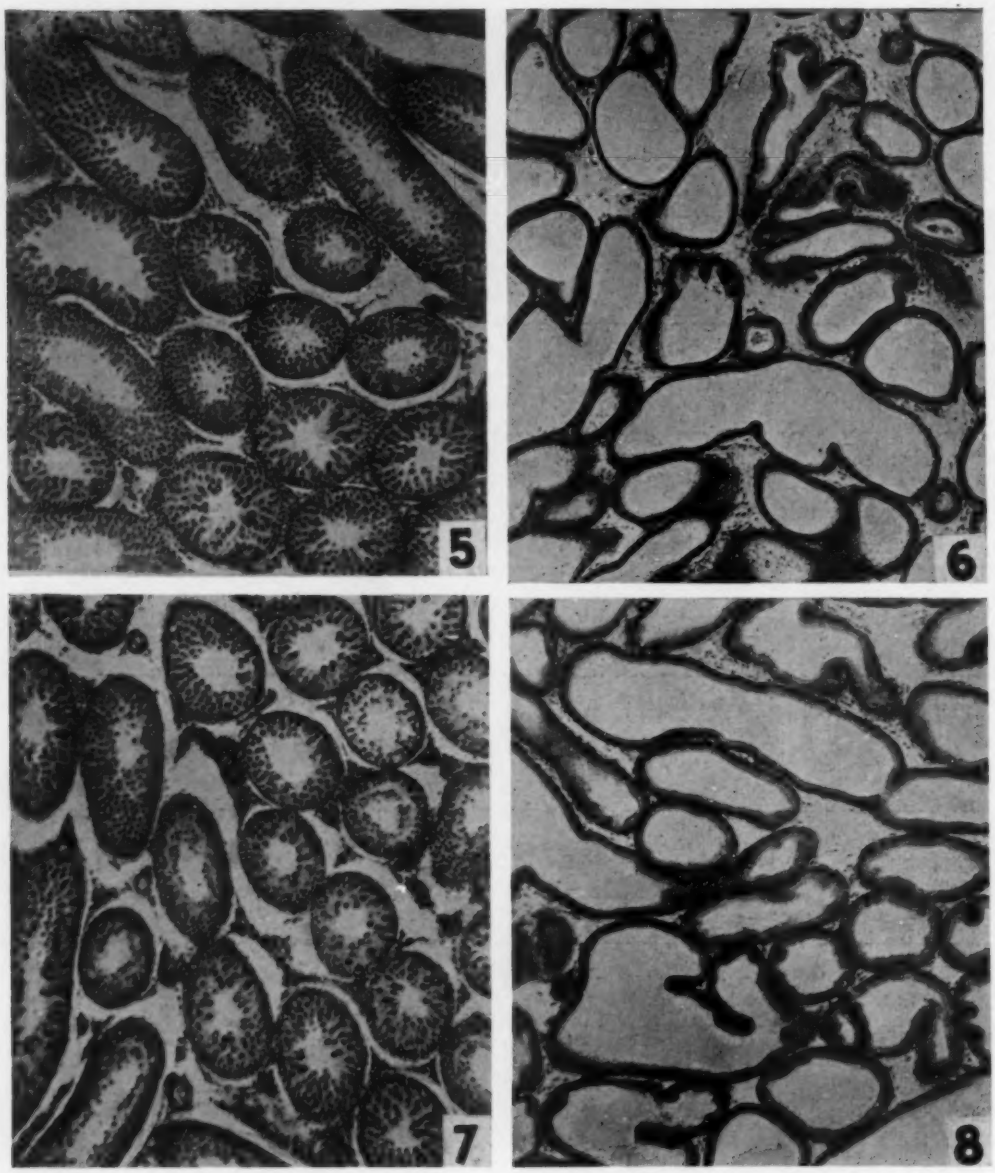

FIG. 5 (×70). Section of testis of untreated rat W-02. Note abundance of spermatocytes and thin, sparsely scattered strands of Leydig interstitial tissue.

FIG. 6 (×70). Section of prostate of same rat (W-02). The epithelium is mostly cuboidal, but in a few acini a high cylindrical epithelium and signs of beginning secretory activity may be seen.

FIG. 7 (×70). Section of testis of rat BH-16. No roentgen irradiation; 35 units of prolan. Note proliferated Leydig tissue.

FIG. 8 (×70). Section of prostate of same rat (BH-16). All of the acini show a high cylindrical, secreting epithelium and numerous mitotic figures. This picture is typical of all animals receiving prolan, including the irradiated groups.

Sertoli cells (Fig. 12). That the destructive direct action of the roentgen rays was sharply limited was clearly shown in the testes that were only partially exposed (Figs. 2, 9 and 10).

As was expected, prolan caused no detectable increase in the weights of even the non-irradiated testes (Group 4), but a definite hyperplasia of Leydig tissue occurred in all injected animals (Figs. 7, 9

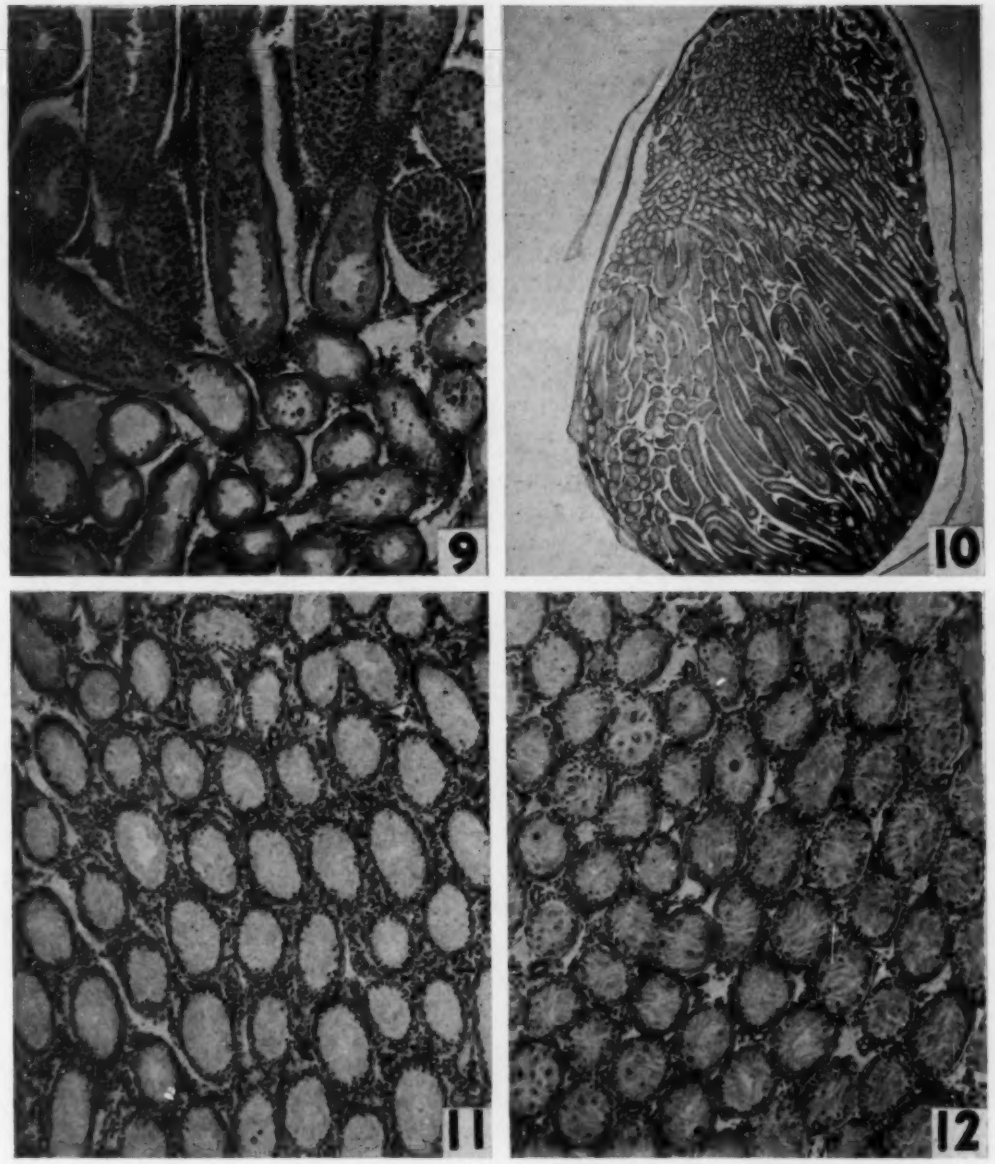

Fig. 9 (×70). Section of testis of rat BH-74. The lower half of the testis receiving 4,608 r shows a proliferation of Leydig tissue (in response to 35 units of prolan) somewhat less than the non-irradiated upper half.

Fig. 10 (×10). Same as Figure 9. Note sharp demarcation of the irradiated from the non-irradiated lower half of testis.

Fig. 11 (×70). Section of testis of rat W-29. Whole testis received 1,152 r; 35 units of prolan injected. Besides an apparent concentration of the stroma due to contraction of the organ, the Leydig interstitial cells have become enlarged and proliferated.

Fig. 12 (×70). Section of testis of rat W-46. Whole testis received 1,152 r; no prolan. All of the seminiferous epithelial cells have been destroyed, except the basal layer consisting of Sertoli cells and probably some spermatogonia.

and 11). The stimulated Leydig tissue caused approximately 50 per cent increase in the weights of the prostate and seminal vesicles in the non-irradiated rats, and those with one-half of a testis irradiated (Groups 4, 5); but where the whole testis was irradiated the weights of the accessories were merely maintained (Group 6), and the atrophy observed in Group 3 prevented.

Histologic examination showed that the prostates of all of the animals receiving prolan were stimulated. Their epithelium was of the high cylindrical type throughout (Fig. 8) and showed evidence of increased secretory activity, while the prostates of the uninjected rats showed high cylindrical epithelium in but few of the acini, and only beginning signs of secretory activity were observed (Fig. 6).

DISCUSSION

These results may be said to indicate that the dosages of roentgen radiation used were destructive to the seminiferous epithelium (and would thus sterilize an animal), but left the Leydig interstitial tissue capable not only of receiving the stimulus of a growth-promoting hormone, but also of growing, proliferating, and in turn, secreting the male sex hormone (promoting growth of the accessory organs of reproduction) into, as yet, undamaged vascular channels. It is not certain that the irradiated Leydig tissue was wholly undamaged, for the irradiated areas of the testes of rats receiving prolan showed somewhat less stimulation of Leydig tissue than the non-irradiated. Furthermore, in Group 6, where the whole testis had been irradiated and had decreased to one-third of its normal size, the prolan caused mitotic proliferation of the Leydig tissue, and the prostatic cytology showed the effects of male sex hormone, but the weights of the accessory organs were only maintained, not increased.

CONCLUSIONS

1. Direct irradiation (1,152 and 4,608 r) of immature rats' testes caused degeneration of the seminiferous epithelium, but left the Leydig tissue capable of responding to gonad-stimulating hormone (prolan). Judging by the weights and histologic appearance of the prostates, the stimulated Leydig tissue formed male sex hormone.

2. For the duration of the experiment (twelve days) the harmful action of the roentgen rays upon the semi-irradiated testes was sharply limited to the irradiated halves.

Vol. 41, No. 3

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Publisher: Charles C Thomas, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich. Office of publication 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

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Twenty-fourth Annual Meeting: Hotel Jefferson, St. Louis, Mo., May 15-16, 1939.

EDITORIALS

THE AMERICAN ROENTGEN RAY SOCIETY*

ROENTGEN'S announcement of his discovery of x-rays in 1895 aroused the interest of the entire scientific world, and those engaged in the fields of pure science and medicine immediately began to experiment with this new agency. It soon became apparent that if radiology were to survive it must be put upon a scientific basis and the desirability of an organization to aid in the accomplishment of this purpose became evident. The American Roentgen Ray Society was organized with the avowed purpose of "the advancement of the science of Radiology and its maintenance as a specialty in medicine." This Society, in its efforts to attain its objectives, fosters the advancement of the science of radiology by every means at its command, and an evaluation of its success in achieving its purposes may be obtained by a review of the contributions of its membership to the advancement and development of radiology.

The position of radiology is now well established in the practice of medicine, but various new movements have appeared and new influences have been invoked which may materially retard the progress of its development. Strange as it may seem, one of the problems which now confronts radiology is the direct result of its very rapid growth and of the important part which it now plays in the diagnosis and treatment of disease. Radiology touches so many branches of medicine that workers in other fields have attempted to familiarize themselves with it as it is applied to their own particular specialty. This is a natural development which cannot and should not be checked. The wisdom of such a policy will at once become apparent to anyone considering that some of the most important advances in radiology have been made by those other than radiologists. Fears have been expressed that this policy will result in the gradual elimination of radiology as a specialty, but this will not occur so long as radiologists possess the requisite skill and knowledge to dominate the situation. This does not mean that organized radiology will idly permit the lowering of the standard of its practice by those who may be unqualified; it has organized the American Board of Radiology, one of the chief purposes of which is the maintenance of a high standard of qualifications for the practice of our specialty.

The entire medical profession is being criticized from both within and without for its alleged failure to supply proper medical care to the public and many of the plans which have been either proposed or put into practice to correct this supposed failure have created special problems for the radiologists. Some of the plans have considered radiology as a part of the hospital services and have failed to recognize that it is a part of the practice of medicine. Such plans are, of course, unsound, because if they are permitted to operate they undoubtedly will retard the progress of radiology. If we are to be successful in our campaign of opposition to these movements we must enlist the support of the rest of the profession, and the first requisite in obtaining that support is the education of our fellow practitioners as to the position of radiology in medicine. Some of them are woefully ignorant of that position and we cannot hope to be successful until they are thoroughly enlightened. Organized radiology should declare its principles in no un-

* President's Address before the Thirty-ninth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 20–23, 1938.

certain terms, but at the same time its policies should be very broad. Methods of practice and economic relationships of the radiologist vary in different institutions and communities, and they cannot be molded into one single plan which will govern all of them. Organized radiology should not compromise its principles but it should resist to the utmost any violation of them; it should not be reactionary in spirit but it should maintain an enlightened interest in the changing conditions by which it is affected. There is no panacea for the solution of our present problems; diligent individual effort for the improvement of our knowledge and active cooperation among ourselves seems to be the proper course for us to maintain. The American Roentgen Ray Society, following its traditional policy, always will support these movements for the protection of the specialty, ever realizing that the lapse of time creates new situations which may have to be treated by newer methods.

John W. Pierson

LEOPOLD JACHES
1874-1939

The death of Leopold Jaches at the age of sixty-five removes from the councils of radiology a wise and dependable counsellor and from the ranks of radiologists a pioneer and leader whose place will long remain unfilled.

Born in Russia in the province of Courland, now a part of Latvia, Dr. Jaches came to the United States at nineteen years of age. From the beginning he cast his lot with his adopted country, was naturalized at the earliest possible moment, and through his entire adult life upheld the institutions and the democratic ideals of the United States of America. His service in the Medical Department of the United States Army during the World War was characteristic of his unostentatious patriotism during his entire life. He entered the service with the rank of captain in the very early days of the war in the spring of 1917, subjected himself to special training in military roentgenology, was promoted to the rank of major and served in France during the entire active participation of our army in the war. When the war was over he remained in France at great personal sacrifice in the position of Senior Consultant in Roentgeology of the A. E. F. He returned to America in 1919 with the rank of lieutenant-colonel and resumed his practice in New York City and his position as head of the radiological department of Mt. Sinai Hospital.

Few men among radiologists have had such a long continuous service as chief of a great radiological department as had Dr. Jaches. He became head of the department at Mt. Sinai immediately upon his return from a period of study with Albers-Schönberg in the year 1908. From then until his death, with the exception of the time of his absence during the war, he was continuously on duty as the director of the radiological department of that institution. There he was held in the highest esteem by his medical and surgical colleagues throughout the long years of his service.

It is impossible here to recount the many contributions of Dr. Jaches to medical science. They are recorded in the medical literature for the past thirty years and are a part of the total achievement in the field of radiology during this pioneer period. He was not a prolific writer but everything he did was in the true scientific spirit, that combination of vision and skepticism which makes for true progress. He carried

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LEOPOLD JACHES
1874–1939

this spirit over into the field of clinical medicine where as a diagnostic consultant his opinion was constantly sought by his colleagues in every branch of medicine. As a teacher of radiology his influence will be felt for many years through the work of young men who received sound instruction from him.

From the earliest days of his practice Dr. Jaches was a supporter of organizations for the advancement of medical knowledge. He was faithful in attendance at meetings, local, national and in foreign countries, and throughout the years assisted in the countless details which make such organizations successful. His place will be difficult to fill in the American Roentgen Ray Society of which he was president in 1931, in the Radiological Society of North America of which he was a faithful member, and on the American Board of Radiology where his counsel was highly valued. At the convocations of the American College of Radiology, the meetings of the Section on Radiology of the American Medical Association and at all the other numerous conferences of radiologists his sane advice and constructive criticism will be missed for years to come.

Jaches, the man, was well known to only a comparatively few whom he especially honored with his friendship. To most people who met him he was reserved and even gave an impression of diffidence. To his intimates it was known that these were marks not of weakness of character but of self-discipline and a singular lack of egotism. In matters of principle or honor he was strong as steel. He was always a mild and gentle man but in pursuit of a purpose there was an inflexibility about him which had its basis in a strong will. One of his most outstanding characteristics was his hatred of sham either in the scientific field or in his personal relations.

The world has lost not only a great physician and scientist but a man of noble character and high ideals. The friends of Dr. Jaches everywhere share with Mrs. Jaches the sorrow and sense of loss which are her special burden in this sad hour and they extend to her and her daughter the deepest sympathy in their bereavement.

Arthur C. Christie

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. C. B. Peirce, Royal Victoria Hospital, Montreal, Canada. Annual Meeting: Chicago, Ill., Sept. 19–22, 1939.

American College of Radiology
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa. Next Meeting: Jefferson Hotel, St. Louis, Mo., May 17, 1939.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: St. Louis, Mo., May 15–19, 1939.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Atlanta-Biltmore Hotel, Atlanta, Ga., Dec. 11–15, 1939.

Radiological Section, Baltimore City Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets twice annually in May and September. Special meetings may be called by the Chairman.

Radiological Section, Los Angeles Co. Med. Soc.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. Harry Hauser, 3395 Scranton Rd. Meets at 6:30 P.M. at Mid-Day Club rooms on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. E. A. Schmidt, 4200 E. 9th Ave., Denver, Colo. Meets third Tuesday of each month.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida State Radiological Society
Secretary, Dr. J. H. Lucinian, 403 Huntington Bldg., Miami, Florida. Meetings held twice a year, May and November.

Georgia Radiological Society
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets twice annually: in November and at annual meeting of Medical Association of Georgia in the spring.

Illinois Radiological Society
Secretary, Dr. E. P. Halley, Decatur and Macon County Hospital, Decatur, Ill. Meetings held quarterly, time and place designated by president.

Indiana Roentgen Society
Secretary, Dr. C. C. Taylor, 23 E. Ohio St., Indianapolis, Ind. Meeting held the second Sunday in May annually.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N.Y. Meets at Kings County Med. Soc. Bldg. on fourth Thursday, each month, October to May, 8:30 P.M.

Michigan Association of Roentgenologists
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

Minnesota Radiological Society
Secretary, Dr. H. M. Weber, Mayo Clinic, Rochester, Minn.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets first Wednesday of each month, at 6 P.M., at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. W. J. Marquis, 198 Clinton Ave, Newark, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

New York Roentgen Society
Secretary, Dr. R. D. Duckworth, 170 Maple Ave., White Plains, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year—January, May, November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport, Pa. Annual meeting, May, 1939. Exact time and place to be decided.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St

Pittsburgh Roentgen Society
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave., Meetings held second Wednesday each month, 4:30 P.M., October to June at various hospitals.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St., Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

St. Louis Society of Radiologists
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Fran-

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

cisco. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

South Carolina X-Ray Society
Secretary, Dr. Hillyer Rudisill, Jr., Roper Hospital, Charleston. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg. Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. H. C. Harrell, 517 Pine St., Texarkana, Texas. Next regular meeting in Temple, Texas, 1939.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. V. W. Archer, University Hospital, University, Va. Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussion.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during month of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgensellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the fall.

Societa Italiana Radiologia Medica
Secretary, M. Ponzio, University of Turin, Prof. Turin

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime:

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

BULLETIN OF THE INTER-SOCIETY COMMITTEE FOR RADIOLOGY

THE ECONOMIC STATUS OF RADIOLOGY UNDER SOCIALIZED MEDICINE

A REPORT ON GERMANY*

In Germany the health of the individual is controlled by the government from the cradle to the grave. Socialized medicine in some form has been in effect in that country since 1883. At the beginning it was a system of sickness insurance for certain groups and occupations. During the intervening years so many social and medical conditions have arisen and so many controlling laws enacted that today it is a very complicated system. The tendency has been to abolish the establishment of separate funds and to care for the masses on a wage earning or income basis. The benefits to be paid to a workman during illness; his care and that of his immediate family; the premiums to be paid for such service and the class of care to be given are all regulated by law.

In Germany at the present time there are four kinds of health insurance:

1. The community or local obligatory insurance (Orts- und Betriebskrankenkassen).
2. The obligatory commercial health insurance (Ersatzkassen).
3. The private insurance companies (Privatkrankenkassen).
4. The welfare authorities (Wohlfahrtsämter).

The welfare authorities are not insurance companies in the proper sense of the word, but are institutions supported by the state or community funds for the treatment of the poor. The funds used for the care of the poor are derived from taxes and donations and are similar to welfare disbursements in America. The individuals receiving benefits do not contribute or pay premiums as in the case of the insured persons, in other words such benefits are purely charity.

All employed persons who earn 300 marks and less a month are legally obliged to be members of one of the health insurance companies mentioned under 1 and 2. The commercial insurance companies are only entitled to admit members of the commercial professions. The commercial members can choose between the first two forms of insurance.

With an income above 3,600 marks a year it is understood that a person can afford to pay for his medical services or has saved enough to care for himself or members of his family in event of a catastrophic illness. Due to the income stipulation for employed persons and with a fairly high income bracket, it is compulsory for the greater part of the wage earning population to carry some form of health insurance.

The obligatory insurance is regulated by the government and in each community is the local, or Ortskrankenkassen. Private insurance companies promoted by private capital are as strictly controlled by the government regulations as are the other types of health insurance.

The private insurance companies—Privatkrankenkassen—admit all persons who wish to have an insurance protection against disease independent of their monthly income. Members of the private companies are also various other persons, such as the state and community officers of the lower classes and such persons as independent workmen are therefore not admitted to the legal health insurance, although they have an income of less than 300 marks per month. In addition those wealthy persons who wish to have health insurance may obtain a policy from the private companies. Therefore many of those of moderate means who may do so belong to the Krankenkassen. In a way it is only the wealthy and those who do not care to purchase protection that are to be found without insurance.

The premiums are different in different classes, and according to the premiums the disbursements in money are also different. It is usual that in the higher classes not more than 80 per cent of the doctor's bills are paid to the members or subscribers. In this way the companies avoid a too frequent calling of the physician by the patient. The amount for hospitalization, operations, roentgen examinations, roentgen treatment, etc., is paid in full in the highest contribution class and only in percentages in the lower classes.

The affairs of the local Orts are administered by a committee who are elected so that of the group two-thirds represent the employees and one-third the employers. This committee must see that each Orts is self supporting and that the money received is sufficient to pay all salaries, benefits, fees, disbursements, administra-

* Prepared at the request of the Inter-Society Committee for Radiology by Dr. S. W. Donaldson, Ann Arbor, Mich.

tion costs and to provide for buildings and their upkeep.

Patients under the health insurance scheme are allowed to select their doctor or hospital. When one becomes a member of one of the obligatory insurance plans he is furnished with an alphabetical list of physicians and specialists in his community. If the patient does not consult one of the approved physicians then he must pay the bill himself. Ward class hospital care is provided and if he prefers better accommodations he must pay the difference and if he prefers a private physician then he must also pay that fee. In case of illness or injury the insured must obtain from the Krankenkasse a permit or sickness slip (for which he pays a separate fee) and this slip authorizes the physician to render service. The contracts provide for a specified number of weeks of medical or hospital care each year. There are approximately 7,000 approved Krankenkassen in operation in Germany at the present time.

The financial scheme of the sick was devised after a study of the cost of medical care. Since its inception the premium paid by each worker from his monthly income has varied from below 2 per cent to over 6 per cent. At the present time it is about 3.5–4 per cent. One-half of this premium or contribution is paid by the employer and one-half by the employee. The average contribution for a wage earner up to 300 marks a month is 3 per cent and for those with a higher salary the average contribution is accordingly higher. That is, a sliding scale prevails as it pertains to the income, the contribution and to the benefits.

Thus about 80 per cent of the entire population are subscribers to some form of health insurance. The medical treatment for these subscribers and all accommodations in the ward class of the hospitals including operations, roentgen examinations and treatments are free.

The remuneration paid to those doctors who are admitted to the legal and obligatory health insurances (Krankenkassen) is a very small one. A physician can make only a modest living from such work and must see many patients a day and obviously has little time for study or recreation.

The obligatory commercial health insurance plans (Ersatzkassen) pay a little more and thus the physician who has many commercial employees as patients can expect to better his income.

The private health insurance companies (Privatkrankenkassen) do not pay to the physician directly, but only to the members. They demand from the members that the physician's bills must be balanced by the patient himself before they give any compensation. The company allows the member 80 per cent of the total amount and the patient pays the other 20 per cent and, as stated above, this procedure tends to discourage the patient from too many visits to their doctor.

All of the health insurance companies are strictly controlled by the government and a special authority (Reichsversicherungsamt) has been set up for this purpose.

Any approved physician is entitled to make roentgen examinations for the purpose of a first orientation. This is especially true in regard to roentgenoscopic surveys. A special commission made up of radiologists has the power of extending to general practitioners the privilege of making roentgenograms. This commission also investigates the qualifications of the specialist. This commission considers his professional education, his special training and his equipment. It also passes upon his qualifications to administer roentgen therapy and in addition may test the accuracy of his instruments for the measurement of dosage. In addition to its duties of determining the qualifications of men seeking to enter the field of roentgenology, it has control of the settlement of accounts of the radiologists for services rendered to health insurance patients.

The commission is entitled to approve diagnosis and the quality of films. This is intended to avoid inferior work by recognized radiologists and to improve or eliminate those men who show insufficient training. This control commission, organized by the radiologists, in a way guarantees that the insurance companies pay only for a high grade of work. The radiologists feel that it has been advantageous to them in that it has upheld the grade of work accepted by the insurance companies and they in turn realize that they can well afford to pay reasonable fees as long as a high standard is maintained. In all cases it has been desirable to have a representative of the insurance company as a member of such a commission.

Specialists are only entitled to make roentgen examinations and to administer roentgen therapy in their specialty, e.g., the surgeon is not allowed to examine a stomach, the dermatolo-

gist may give only superficial therapy, etc. All deep therapy must be administered by an approved radiologist.

In Germany there are four sources of roentgenological consultation available to all physicians.

1. The central roentgen departments in the large hospitals. All patients of all departments of the hospital are examined or treated in these central departments under the direction of some prominent roentgenologist and his assistants.

2. Special roentgen departments in the different branches or departments of the university clinics and some large hospitals. Such departments are not as numerous as generally believed and a great deal of their time is devoted to research. By dismembering radiology as a unit and establishing a unit for each specialty there is a tendency to develop specialists within a specialty. Such a situation is probably inevitable in very large departments.

3. The central roentgen department of some of the large public health insurances (Krankenkassen). The insurance companies exert pressure upon their members to go to these institutions and in this manner are the greatest competition to the private roentgenologist and to the roentgen departments of the hospitals.

4. The roentgenologist with a private office and at the same time possibly in charge of the roentgen department of one of the smaller hospitals on a part time basis. The private office practices exist only in the cities and large metropolitan centers, as a small town could not support such a practice. The ability to show a profit in such an office is directly dependent upon the number of patients. The small fees paid by the public health insurance groups are sufficient to maintain a private roentgen practice if a minimum number of 150 patients monthly are examined or treated. If as many as 300 patients are seen each month then a profit can be expected. The earnings of a private office practice having more than 300 patients are sufficient for a profit and also a reasonable renewal of equipment and the purchase of additional improvements. Offices with less than 300 patients monthly will have considerable difficulty in respect to purchasing new equipment or replacing old and obsolete machines unless the greatest economy is exercised and excellent care given to the equipment already installed.

The greatest competition for the private roentgen office is radiological departments of the local or community health insurance organizations. As all roentgenological work must be agreed to by these organizations before it can be carried out, it is necessary for the patient to go to the large and modern buildings which have been built, the Orts or local insurance company. This gives them the opportunity to urge the patient to go to the so-called "Eigenbetrieben" e.g., the proper department.

The compensation for the radiologist's hospital work is often a fixed salary from 400 to 800 marks per month and in some of the larger institutions a higher salary is paid. In smaller departments the radiologist gets a percentage of the receipts, usually after a deduction of a certain rate for the cost of films, chemicals and other overhead expenses.

For the diagnostic roentgen service as well as for therapy there are regulations which determine the amount of roentgenoscopy allowed or the number and size of the films to be made for every condition. These restrictions have been made to prevent unnecessary films and to require the roentgenologists to be extremely economical. In case the roentgenologist deems it necessary to make additional exposures and use more than the allotted number of films in order to arrive at a diagnosis he must do so at his own expense, or give special reasons why more than the allotted number of films were necessary. The roentgenologist must have a large number of patients in order to absorb any deficit occurring in such a manner. It is argued that any deficit incurred on a patient in this manner may be made up by doing fewer films on a number of other patients.

The German Roentgen Society (Deutsche Röntgengesellschaft) has agreed upon rates for the expenses incident to each examination and these figures are the basis of the different tariffs. The German Roentgen Society is consulted by the authorities in all difficult economical questions pertaining to roentgen diagnosis or roentgen therapy. A close cooperation between the radiologists and the practitioners is urged and desired and it may be said that it exists in most cases from a medical viewpoint but in matters of economics their interests are sometimes divergent.

There are twoma in tariffs for radiology in Germany: the "Preussische Gebuehrenordnung" (Preugo) and the "Allgemeine Deutsche Gebuehrenordnung" (Adgo). The "Preugo" dis-

tinguishes a rate for costs of films, material, etc., and a rate for the radiologist's fee including the report. The rate for the costs is different according to the size of the films used.

Size: 9×12 cm.	13×18 cm.	18×24 cm.
3.0	4.50	5.20
24×30 cm.	30×40 cm.	Fluoroscopy
6.0	7.75	3.25

The fee for the radiologist is 5.0 marks for the first exposure or as termed application of the roentgen apparatus and 3.35 marks for the second and subsequent applications up to five during the same examination. A few examples of the method used in submitting charges as allowed are as follows.

Complete Examination of the Chest. One fluoroscopy and one film 30×40 cm. For this is paid 7.75 marks for the film and 3.25 marks for the fluoroscopy making a total of 11.00 marks for expenses and in addition the radiologist receives a fee of 5.0 marks for the first application, filming the patient and 3.35 marks for the second application during the same examination or a total of 19.35 marks or at the present rate of exchange of approximately 40 cents a mark the equivalent of $7.65.

Complete Gastrointestinal Examination. Three fluoroscopies are allowed and at most two 18×24 cm. films and one 24×30 cm. film making a total of five applications of the roentgen apparatus. The fee for this is 21.75 marks and the expenses paid are 25.35 marks making a total for the examination of 47.10 marks. A complete examination with the above number of films and fee is paid only in complicated and difficult cases. The total fee for the average gastrointestinal examination is about 35.0 marks.

Gallbladder Examination. Two 18×24 cm. films and one 24×30 cm. film. Fee 11.75 and expenses 15.60 marks for a total of 27.35 marks.

Examination of the Knee Joint. Two exposures on one 24×30 cm. film, fee 8.35 and expenses 11.00 marks or a total for the examination of 19.35 marks.

Examination of the Hand. Two exposures on one 13×18 cm. film, fee 8.35 and expenses 4.50, total 12.85 marks.

The "Adgo" has only a so-called "organ tariff" which is higher than the "Preugo." This tariff provides a fixed payment for examination of the different organs, for example: Lungs—28 marks, stomach and duodenum—35 marks, complete gastrointestinal—50 marks, wrist—15 marks. This tariff is paid by all commercial obligatory insurance organizations (Ersatzkassen). A complete examination including fluoroscopies and report is to be furnished for these rates, independent of the number of films used or number of applications of the roentgen apparatus.

For radiation therapy the "Preugo" and the "Adgo" distinguish between superficial and deep therapy. The regulations for therapy are as follows: In superficial therapy the fee paid is per area. The fee paid is for the treatment of one field with the so-called effective dose irrespective of the number of applications or "sittings" or of the filtration used. The fee paid per area is for irradiation of that area 5.0 marks plus 5.0 marks for expenses. The maximum size of an area is 17×17 cm. and six areas are paid for in every single disease. A large amount of superficial therapy is carried out by the dermatologists in their own offices and because of these innumerable treatments the tariff has been made low, 10 marks per field, in the "Preugo" and 15 marks in the "Adgo."

For deep therapy, only allowed to be carried out by approved radiologists, the "Adgo" pays somewhat more than the "Preugo"; for instance, a complete treatment for cancer of the uterus costs approximately 135 marks in the "Preugo" and 155 marks in the "Adgo." Deep therapy charges depend upon the effective dose and in carcinoma of the uterus the fee amounts to 100 marks and the expenses allowed are 35 marks. The effective depth dose for such a treatment is set at 2,500 r.

The prices for work done by private radiological offices corresponds in general with the price of the "Adgo." Only a few prominent radiologists get more. In cases of legal proceedings the "Preugo" is taken as the basis for discussion by the authorities.

A new general German tariff for all medical work has long since been announced by the present medical authorities but it has not yet gone into effect. According to the best private information available the fees for radiology will be between the prices now in force in the "Adgo" and the "Preugo."

The radiologists have no direct settlement with the patients whose insurance is compulsory. The settlements with the legal insurance companies go by way of an organization which is directed by physicians. All receipts of

the obligatory insurance organizations are carefully checked by the controlling medical organization to see whether the individual physician exceeds the average of other physicians in his bill both as to amount charged and to the amount of work done. Reductions occur in all cases where the amount of the physician's bill is too high.

The medical organization pays to the radiologists as well as to all practicing physicians a round sum which is derived from the amount paid in by the members of the insurance company. Payments are made every quarter and a final settlement is made at the end of the last quarter of the next year. At the time of the final settlement, if a difference exists between what the physician has been paid and what is due to him he is credited with the amount due him or if overpaid that amount is charged against him.

In preparing the schedule of expenses all existing costs such as films, chemicals, a percentage of rent, technicians' salaries, depreciation on equipment and minor overhead expenses were given consideration.

Every physician is obliged to give exact reports about his patients. A report is transmitted to the insurance company, one to the examining board and one must be retained by the radiologist. The following information must be sent on each patient to the commission which settles the account, or the bills submitted to them by the radiologist.

1. Name, Christian name, age of the patient.
2. Statement of the disease.
3. Kind of radiologic treatment. If diagnostic services were rendered the number of fluoroscopies as well as the number and size of the films must be included. If therapy then the number of irradiations and the total "r" dosage must be given.
4. The roentgen diagnosis.
5. Name and address of the referring physician.
6. Calculation of charges divided into expenses and fee.

In summary of this report it may be said that the following important factors show the present set up of the economic status of the radiologist in Germany.

1. All employed persons in Germany with an average monthly income of less than 300 marks must be in an obligatory insurance organization.
2. All other persons can buy a policy of a private insurance company protecting them in case of illness or disease. The compensations paid are dependent upon the contribution or premiums paid into the company.
3. About 80 per cent of the population of Germany is in one of the various insurance schemes.
4. The radiologist is paid according to two different tariffs, the "Adgo" and the "Preugo."
5. The profit making ability of a private roentgen practice is strictly dependent upon the average number of patients each month. The minimum number is considered to be 150.
6. The greatest competition is that of the roentgen departments of the obligatory insurance companies.
7. Radiology is practiced in Germany by central roentgen institutes, special roentgen departments, private offices and the roentgen departments in the general hospitals.
8. Payments for radiological services are made by a special commission of radiologists who supervise the qualifications of those desiring to practice radiology and audit all accounts submitted.

Germany today has a very large number of the population under a strictly regulated socialized medical scheme. The paper work, and as termed in this country "red tape," is a tremendous task although probably not as much as for the occasional WPA case seen by the private practitioner in this country.

As has been shown the min mum number of patients per month necessary for operation of a roentgen office at a profit is 150. In view of this fact, it is interesting to make comparisons of the fees allowed in Germany, and the present fee schedule was adjusted and arranged in consultation with the German Roentgen Society, with the fee schedule adopted and put into effect in this country by the CWA and carried on to the WPA. Considering the present rate of exchange of 40 cents for the mark the fee allowed under socialized medicine in Germany for the roentgen examination of a hand is $5.14 and the WPA allowance (if claim is not disallowed) is $2.50. For a knee the fee is $7.74 and WPA $2.50; a chest $7.65 as against $3.75, and for a complete gastrointestinal $18.84 as compared to $12.50. Undoubtedly the experience of the

German system since its introduction has produced better cost accounting in the matter of radiologic examinations than that used by the authorities who suggested the CWA and WPA fee schedule for such services.

It is easy to see that the administration costs of operating such a system of socialized medicine are great. The fees paid to the general practitioner must of necessity be low in order to pay the physicians on salary, the nursing staff, druggists and lay clerical help. An enormous sum is already invested in the buildings and equipment, and maintenance costs and replacements must be taken from the money paid in by the workers. It therefore stands to reason that, in order to meet the administration costs and pay salaries to the large number of employees, very little is left to be apportioned to the physicians for their professional services. It is needless to say that the specialists fare better than the practitioner under such a system.

I desire to thank those radiologists in Germany who were kind enough to give me information on economic matters pertaining to the practice of radiology, and also to thank Dr. Seilman of New York and Dr. Marum of Greenville, Miss., for their suggestions and criticisms in preparing this report.

GEORGIA RADIOLOGICAL SOCIETY

The Georgia Radiological Society held its Fall meeting on December 13, 1938, at the Macon Hospital, Macon, Georgia. The program consisted of a short business session, a diagnostic round table, a paper by the guest speaker, Dr. Hillyer Rudisill, Charleston, South Carolina, on "Timing in Radiation Therapy," and a symposium on "Radiation Therapy in Breast Tumors" conducted by Dr. Thomas Harrold, Macon. The Society was entertained at luncheon by Dr. C. L. Ridley, Superintendent of the Macon Hospital.

The following officers were elected to serve until November, 1939: President: Dr. J. J. Clark, Atlanta; Vice-President: Dr. L. P. Holmes, Augusta; Secretary-Treasurer: Dr. R. C. Pendergrass, Americus.

So much enthusiasm and interest were shown during the diagnostic round table that it was voted to hold an interim meeting at Columbus, Georgia, in March, 1939, with Dr. William F. Jenkins and Colonel C. A. Stammel as joint hosts.

AMERICAN RADIUM SOCIETY

The Twenty-fourth Annual Meeting of the American Radium Society will be held at the Jefferson Hotel, St. Louis, Missouri, on Monday and Tuesday, May 15 and 16, 1939. The morning and afternoon sessions will be devoted to scientific papers on a variety of subjects dealing with radium, and roentgen therapy and tumors. The Janeway Lecture on Monday evening will be delivered by Dr. G. Failla of the Memorial Hospital, New York.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

Textbook of Diagnostic Roentgenology. By Lewis J. Friedman, M. D., Director, Roentgen-Ray Department, Bellevue Hospital; Instructor in Radiology, New York University College of Medicine; Chief Radiologist, Stuyvesant Polyclinic, etc. Cloth. Price, $10.00. Pp. 623, with 638 illustrations. New York: D. Appleton-Century Company, Inc., 1937.

The publication of this volume is an effort by the author to include within 623 pages the entire subject of diagnostic roentgenology. He states in his preface that brevity had to be exercised in view of the vast ramifications of roentgenographic diagnostic procedures in the various branches of medicine and surgery. He hopes that the radiologist may find it a helpful reference medium, especially in the consideration of the less common pathological conditions.

Part I covers the physics of the roentgen ray, fluoroscopy and other roentgenographic procedures, roentgenographic accessories and dark room technique. Part II includes the osseous system with a chapter on roentgenographic technique of the examination of various portions of the skeleton. The respiratory and cardiovascular systems and the alimentary and genitourinary tracts then follow in order. Included under each is a description of technique necessary for proper examination.

The book is printed in excellent type and is well edited. Roentgenograms are reduced and retransposed to their original black and white, or negative form, which lends to more accurate depiction of the roentgen findings in the original films. Another good feature is the placing of the roentgenograms in close proximity to the subject matter under discussion. Owing to the necessity for brief description, the text is, in many instances, no more than a catalogue of disease with definitions and illustrative roentgenograms. In the classification of bone diseases, the inclusion of Ollier's disease under achondroplasia or chondrodystrophia foetalis is unusual and is open to question. In the description of the osteochondritides, the vertebral type of Scheuermann is discussed but no mention is made of the type described by Calvé. Newer technical procedures, such as kymography, are included. The chapters on the genitourinary tract and pelvimetry are concise but adequate.

The lack of sufficient description of underlying pathological processes as a cause for roentgen changes impairs the value of this work as a reference book for the trained roentgenologist. With due appreciation of the handicap of curtailment of the text, the author reiterates the necessity of a knowledge of pathology because of its practical application in the interpretation of aberrant roentgenographic shadows. The references at the end of each portion of the book are sufficient to furnish means for further study. For the student of roentgenology the book will be extremely useful.

Ralph S. Bromer

Stratigrafia: Metodo röntgenologico per la esplorazione analitica dei singoli strati sovrapposti. Allesandro Vallebona. Monograph in 2 volumes. Volume I, 100 pages; Volume II, 162 illustrations. Paper. Price, L. 50. Roma: Casa Editrice Luigi Pozzi, 1938.

(This monograph, which the author dedicates to the 25th anniversary of Vittorio Maragliano, received the "Premio Ferrania," a prize of 10,000 lire of the Societa Italiana di Radiologia Medica.)

Stratigraphy, introduced by the author in 1930, is a method of dissociating superimposed roentgenographic shadows so that a detailed and clear roentgenogram may be obtained of body structures at any desired level. In the first volume Vallebona discusses the geometric foundations (laid by Bistolfi) of his method and describes various ways in which the problem may be solved. In the second volume he describes and illustrates his own latest apparatus as well as roentgenograms produced thereby. He makes no exaggerated or extravagant claims for this diagnostic procedure but points out its advantages, possibilities and limitations in the study of the skull, spine, chest and other structures, with particular emphasis on the dif-

ferential diagnostic data which stratigraphy may furnish. There is a bibliography of 138 references. This monograph is a very important contribution to this new and popular subject.

E. T. Leddy

Le traitement radiologique de l'actinomycose. Par Axel Renander. (*Acta radiol.* Suppl. xxxv.) Communication de Radiumhemmet et de l'institut Roentgen de l'Hopital Serafimer, Stockholm. Chefs: MM. G. Forssell et E. Berven, professeurs. Paper. Price, Swed. cr. 8.00. Pp. 75. Stockholm: P. A. Norstedt & Söner, 1937.

In this monograph Renander reports the experience of the Radiumhemmet (Stockholm) with the treatment of fifty-two microscopically proved cases of actinomycosis treated between the years 1915 and 1932. During these years the radiotherapeutic techniques have been changed and improved. The present tendency is toward high doses of radiation. The author points out the necessity of making an early diagnosis and some of the difficulties in doing so. He feels that in treatment the use of potassium iodide and of operation are less important than radiotherapy. His results, like those of most authors, were good in the cervicofacial, fair in the abdominal and generally poor in the other cases.

E. T. Leddy

Standards for the Diagnosis and Treatment of Cancer. By The Executive Cancer Committee of the Iowa State Medical Society. Paper. Pp. 168. Iowa City, Iowa: Athens Press, 1937.

"An effective attack upon the problem of cancer control demands the inauguration of a dual educational program," and therefore it must include both the lay public and the medical profession. This little book is addressed to the general practitioner in medicine and serves its purpose well. It is written in simple and concise language and while there are a few minor inaccuracies and debatable statements, it contains a wealth of splendid advice. A few quotations which radiologists will wholeheartedly endorse may illustrate this point: "Destruction of localized lesions by escharotics, such as arsenic paste or sulphuric acid, has been popularized by quacks. Such chemical agents are undoubtedly effective in the treatment of small lesions, but, because they produce so much pain and it is so difficult to control their action, their use should be discouraged" (p. 17). "The use of rented radium by the inexperienced operator usually gives disappointing results and is to be deprecated" (p. 83). "However, it should be emphasized that the grade of malignancy is only one of the factors which determine the prognosis of a given tumor" (p. 151).

The committee of three, A. W. Erskine, F. P. McNamara and E. D. Plass, responsible for the publication, may well be proud of their accomplishment. Here is a suggestion: Would it not be worth while to make a copy of this book available to all our referring physicians?

Ernst A. Pohle

Erbegnisse der biophysikalischen Forschung in Einzeldarstellungen. Herausgegeben von Professor Dr. B. Rajewsky, Direktor des Kaiser-Wilhelm-Instituts für Biophysik in Frankfurt am Main. Band I. Ultrakurzwellen in ihren medizinisch-biologischen Anwendungen. Von H. Dänzer, H. E. Hollmann, B. Rajewsky, H. Schaefer und E. Schliephake. Paper, price RM. 19., bound, RM. 21. Pp. 308, with 188 illustrations and 24 tables. Leipzig: Georg Thieme, 1938.

The results of the investigations of biophysical problems are fairly well scattered throughout the literature and it is not an easy task to correlate the facts recorded in physical, technical, biological and medical journals. Rajewsky has therefore undertaken the publication of a series of volumes, each one consisting of several monographs which relate the present status of our knowledge in a certain biophysical field.

The first volume deals with ultrashort electric waves. Although it is little more than ten years since Schliephake undertook his first experiments in this direction a tremendous amount of work has been done in that short time. The editor himself outlines in a brief introductory chapter the biophysical problems arising in connection with the use of short and ultrashort electric waves. The physical and technical principles are covered by H. Schaefer. He points out that there is no specific wave length for each organ in the body and that shorter waves are apparently more desirable, a good reason for the study of the effect of wave lengths below 1 meter. Rajewsky discusses then the biophysical principles of the effects of ultrashort waves on living tissue. The laws governing high frequency currents are briefly re-

lated and methods and results of the measurements of the conductivity of tissues for high frequency currents as well as changes in their dielectric constants are described. A theory of the behavior of biological objects in the high frequency field is presented by Dänzer, while Hollmann discusses the problems arising in the proper positioning of the body during the exposure to ultrashort waves; after theoretical considerations definite recommendations are made for use in practice. The last chapter, contributed by the pioneer in this field, Schliephake, brings a brief résumé of the clinical aspect of ultrashort wave therapy including his evaluation of the results to be expected in rheumatic disease, diseases of the blood vessels, the endocrine and nervous systems and in ophthalmology. Fever therapy is also discussed. In a short paragraph relating the dangers in the use of short wave therapy, the author concludes that they are minimal in the hands of the experienced operator.

Diathermy, including short wave therapy, is a part of physical therapy. Because of the largely empirical background of this field and many abuses in the past, it is gaining recognition only slowly. If more contributions of a fundamental character and of such a high type as the volume reviewed above are forthcoming, physical therapy will have no difficulty in gaining and maintaining its proper place in medicine.

Ernst A. Pohle

Vol. 41, No. 3

DEPARTMENT OF TECHNIQUE

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A SIMPLE METHOD OF LOCALIZATION AND REMOVAL OF MULTIPLE FOREIGN BODIES

CASE REPORT

By CHARLES F. SEBASTIAN, M.D., *and* SYDNEY V. KIBBY, M.D.
LOS ANGELES, CALIFORNIA

THE search for foreign bodies buried beneath the subcutaneous tissue can be the most exasperating of all surgical procedures and even with the assistance of the roentgen ray and the several methods of application that locate opaque foreign substances, the operation has not been simplified to the degree that a time schedule can be adhered to.

A single case has recently taxed the perseverance and ingenuity of the co-author who has been privileged with more than his share of surgical searches for foreign bodies. Because of the quantity, distribution and depth of the many bits of metal and the more satisfactory method of location and extraction subsequently developed, it is believed that this case history may be of interest and assistance.

On the morning of January 14, the patient entered his automobile and pushed the starter button. An immediate explosion occurred which demolished the car and garage and sent fragments of metal up through the floor boards. The force of the blast fractured the right tibia by comminution at the ankle joint, splitting a V-shaped fragment from the distal end of the bone. A fragment of metal passed through the left forearm shattering the ulna at the proximal third. A deep laceration was torn in the plantar surface of the left foot and several communicating deep lacerations were torn in the anterior, medial and posterior surfaces of the right leg.

Many penetrating wounds were inflicted over both lower extremities, the left upper extremity and the torso below the transverse nipple line, each of which contained a fragment of metal. A thin knife-like fragment passed through the medial surface of the left wrist, and after severing the ulnar artery, lodged in the palmar surface beneath the fascia. A single large fragment embedded itself in the sixth intercostal space within the intercostal muscles, while two smaller pieces of metal lodged in the abdominal wall. Other fragments penetrated the soft tissues of the right thigh, hip and knee and the left thigh, leg and foot.

The early application of tourniquet at the scene of the accident controlled hemorrhage from the ulnar artery. Transportation splints and morphine assisted in the patient's removal to the hospital.

Upon arrival the area around the lacerations was cleansed and infiltrated with 2 per cent novocain. Debridement with the removal of a large quantity of metal fragments was next performed and the lacerated wounds closed with drains, with the exception of one laceration of the right leg which was left open. Splints were applied to the fractures and the patient put to bed with shock treatment and combined gas bacillus and tetanus antitoxin.

Fixation of the fractured tibia and torn muscles of the left leg was accomplished on the second day by the use of a posterior moulded plaster splint bound at the foot and below the knee by circular plaster. The wounds were not dressed, but allowed to drain into receptacles, the skin and plaster being protected with zinc oxide paste and the areas protected with a tenting of a single layer of gauze.

Roentgenograms taken January 17 demonstrated the presence of thirty-eight large pieces of metal and many small metal slivers remaining after the primary exploration and removal of a large quantity of fragments from the wounds. The fracture of the left ulna was fixed by means of a light plaster cast with the forearm at right angles and in supination.

FIG. 1. Roentgenogram of chest with ¼ inch wire mesh locating position of metal foreign body in sixth intercostal space.

A series of operations was then performed for the removal of the embedded foreign bodies, some of which were quite difficult because of the distance they had traveled from the entrance wounds and the inaccuracy in locating them roentgenologically. The first failure was encountered when the attempt was made to extract the fragment in the sixth intercostal space of the left chest. A strip of ¼ inch wire mesh was strapped to the chest wall and roentgenographic record made. The squares of the wire mesh served to graphically locate the fragment in the anteroposterior position as shown in Figure 1, but the thickness of the chest wall allowed for considerable error even with this graphic chart. The depth of the fragment was difficult to ascertain even with the lateral film. After an exhaustive attempt had been made to locate this foreign body without success, two Kelly hemostats were fixed to the fascia in the region the fragment was believed to be lodged. A lateral roentgenogram taken with the hemostats fixed to the fascia demonstrated the exact region of the metal and it was then quickly cut down upon and extracted. Figure 2 shows the metal fragment directly below the more vertical clamp. Subsequent operations were performed with this procedure in mind.

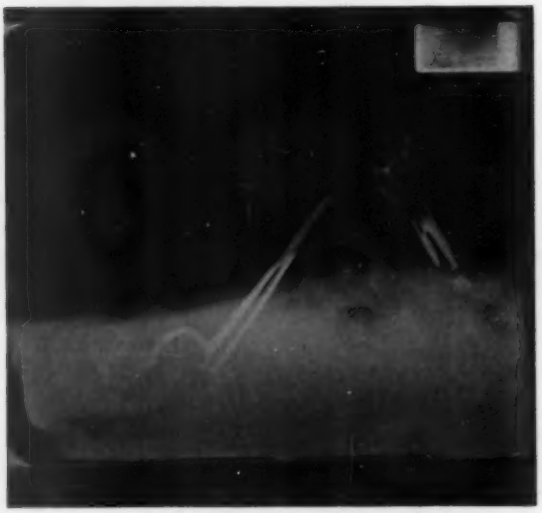

FIG. 2. Lateral roentgenogram of chest showing foreign body and hemostats fixed to fascia.

FIG. 3. Roentgenogram of right knee showing three metal foreign bodies in the popliteal space and hemostat fixed to fascia. A fourth fragment is shown proximal and medial.

The metal fragments in the right popliteal space were quickly extracted as a result of the above experience. The approximate location

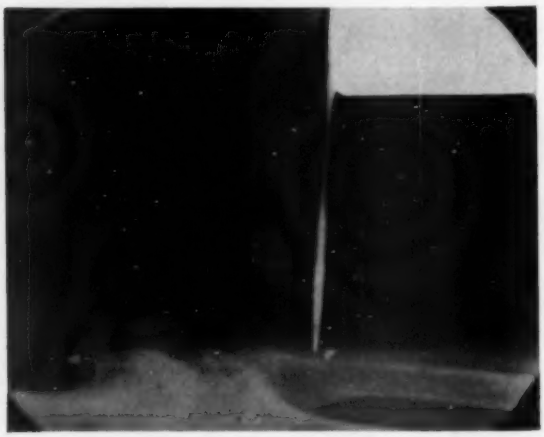

FIG. 4. Roentgenogram same position as Figure 3 with hemostat fixed to fascia near third fragment.

was determined by anteroposterior and lateral films. Fairly accurate determination of the location of the foreign bodies in the anteroposterior plane was calculated. The area was infiltrated with 2 per cent novocain and an incision through the subcutaneous tissue was made over the suspected area. Without further exploration, a hemostat was fixed to the fascia and a lateral roentgenogram taken with the patient remaining in position. The location of the foreign body was easily calculated from the position of the hemostat and quickly removed.

Figure 3 demonstrates a hemostat fixed to the fascia about 1 inch proximal to a foreign body in the popliteal space. The wound was explored at the calculated point and the metal fragment removed. A second foreign body was extracted by exploring at approximately 2½ inches distal to the hemostat as demonstrated in the roentgenogram. The third fragment shown, being in a different plane, was removed by this same procedure, the hemostat being shown in Figure 4 fixed to the fascia adjacent to the metal fragment. The more proximal foreign body shown in Figures 3 and 4 was lodged in the medial portion of the thigh and was later removed by this method, as were fragments in the left leg and right thigh.

Having found the above process wholly successful in eight successive applications, we recommend it for safety and simplicity, realizing it may not be applicable in all instances. In some cases it may be necessary to repeatedly apply and roentgenograph several hemostats before the object of the search is obtained.

The roentgenographic studies of this case were made in the California Hospital under the direction of Dr. Henry Snure.

RADON PACK ARRANGEMENT

By IRVING HANSON BLATZ

Radiation Physicist, Brooklyn Cancer Institute in conjunction with the Physical Laboratory, Department of Hospitals

NEW YORK CITY

ALTHOUGH the idea of using radium emanation in a pack or bomb for external irradiation is not new, we believe our arrangement presents certain advantages from a standpoint of convenience and economy. The adoption of this method grew out of necessity in that about a year ago we had on hand at the Brooklyn Cancer Institute a radium pack stand with no radium to use in it. All gamma irradiation was done with radon from the Division of Cancer Radon Plant at Welfare Island, which also regularly supplies six other city hospitals with radon. A survey of past radon requests showed that the demand for radon on different days of the week varied, depending somewhat on the clinic days at the different institutions and also on the application of radon as not to interfere unnecessarily with week-end leaves. Consequently, on certain days there was a surplus of radon available that would be held over to the following day with a great loss of millicurie-hours radiation. It was also found that many partially spent applicators were returned to the plant with insufficient strength or concentration to permit re-issuance on another order.

FIG. 1. Pack showing tray holders and trays.

A device was constructed to fit in the cavity of the pack so that five trays, each consisting of a disk of aluminum, could be stacked one above the other in a rack (Fig. 1). The glass radon capillaries are fastened to the top of each tray with wax and there are a few studs around the edge of each tray to prevent the one above from resting on the glass. Each of the trays is stamped with a number for reference and there are two spare trays so that there are always five in place even when one is being prepared or transported.

The radon plant has a standing order for all available spare and returned radon to be placed on a tray each week and delivered to the Brooklyn Cancer Institute with the usual certificate of content. In addition, an extra tray is sent whenever sufficient radon is available at other times.

A chart (Fig. 2) is kept at the hospital on which the resident on service enters, for each tray, the tray number, the date and hour of insertion, tray strength and total pack strength. The value of total strength is in addition kept in the form of a decay curve as illustrated so that the strength may be determined by referring to the curve at any hour. (Actually these records are kept on linear cross section paper rather than on semi-logarithmic paper. It is felt that in this way the residents who keep the records as part of their training obtain a better picture of the decay process. They plot the curves from the regular radon decay tables.)

Each week the fresh tray is placed in the lowest position; all other trays are raised one step and the top tray is returned to the radon plant for refilling. Usually the radon content of the returned tray (four or five weeks old) is negligible but a check is kept

and if it is not, its value is deducted from that of the fresh tray.

The radon technicians have been instructed to place the strongest capillaries near the outer edge to keep the depth dose at a maximum.

Skin distance—4 cm.
Filtration—4 mm. lead
Average mean strength—about 800 mc.

Depth Dose Notes. Theoretical depth dose values have been calculated to indicate what depth dose we give and to show for

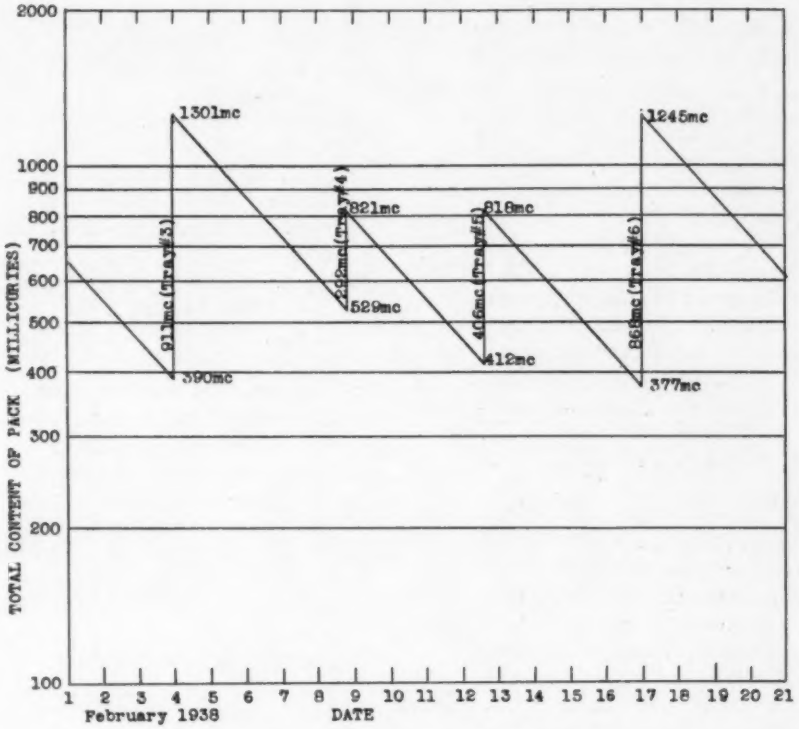

FIG. 2. Typical radon pack chart.

The skin distance is measured to the nearest tray. Calculations have shown that we may neglect the distance variation caused by raising the trays about 3 mm. each week since, as the skin distance error increases each week for a particular tray, its strength and relative importance in the dosage calculations become less.

Occasional ionometric measurements are made on the pack to check the calculations.

Other pack factors are:

this particular setup the advantage of having the radon as nearly concentrated along the periphery of the tray as possible. For comparison the values for a point source are also given.

	Point Source	*Disk Source**	*Circular Source†*
5 cm. depth dose	19.7%	27.2%	35.2%
10 cm. depth dose	8.0%	11.6%	16.5%

* Radon distributed evenly over the entire area of the disk (diameter, 9.0 cm.).

† Radon concentrated near the edge of the disk (diameter, 9.0 cm.). Actual disk diameter, 9.5 cm.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

SKELETAL SYSTEM

Tillier, H., Raynaud, R., and Marill, G. Les aspects de dissociation trabéculaire ordonnée dans la maladie de Paget. (Regular trabecular dissociation in Paget's disease.) *Presse méd.*, June 25, 1938, *46*, 1026–1027.

Sixty years after its description, Paget's disease remains a descriptive clinical entity. The roentgen appearance was described by Legros and Léri in 1909 and consists of trabecular dissociation, transparent or dense areas connected by fine lines forming a tangled skein, like flakes of cotton wool thrown together irregularly. Some authors have called attention to less disorganized structural modifications where the new bone is laid down along the lines of force and in the general direction of the normal bone. The authors have observed this regular dissociation in many different bones, vertebrae, pelvis, long bones, both localized and generalized. This appearance was not noted in the skull where it always appeared to be cotton wool. The essential element is the trabecular dissociation as though the trabeculae were spread apart.

Several types are described, and are classified as follows: (1) felt-like—particularly diaphyses of long bones; (2) grill-like; (3) pseudocystic. The changes are apparently a form of bone reaction and it is hoped the study will help better to place Paget's disease in the classification of other osteopathies.—*M. L. Sussman.*

Pachman, Daniel J. Chronic Gaucher's disease. *Am. J. Dis. Child.*, August, 1938, *56*, 248–265.

Pachman reports 2 cases of chronic Gaucher's disease occurring in 2 negro siblings. These patients had the characteristic changes in the spleen, liver, lymph nodes, blood, bone marrow and conjunctiva. On roentgen examination of the skeleton in the 2 cases, the fusiform expansion of the lower ends of the femurs, which has been considered pathognomonic of Gaucher's disease, was not found. However, generalized osteoporosis and rarefaction of the bones, a more constant finding in cases of the disease were present. The upper ends of the femurs were extensively involved, and as a result, a pathological fracture through the surgical neck of the right femur occurred in one of the children. Tissue cultures of a peripheral lymph node were attempted but Gaucher cells were not grown. Normal blood lipoid values were obtained, with the exception of those for total cholesterol and neutral fat. The ingestion of milk containing 20 per cent cream was followed by normal fat tolerance curves in both patients. The fat in the stools was a normal fat diet, was within the limits for normal children in one case and slightly below in the other. The dextrose tolerance tests resulted in moderately flat curves. In both children, galactose tolerance, Takata-Ara and bromsulphalein tests gave normal responses. The phenolsulfonphthalein test in one case showed a normal rate of excretion.

Roentgen therapy had no effect in one case. Liver extract administered parenterally in one case caused a reticulocytosis and a rise in the hemoglobin content and red blood cells. No change in the size of the spleen was noted.—*R. S. Bromer.*

Sontag, Lester W., and Comstock, George. Striae in the bones of a set of monozygotic triplets. *Am. J. Dis. Child.*, August, 1938, *56*, 301–308.

Narrow lines resembling pencil marks and often traversing only a part of the width of the bone are seen more frequently in roentgenograms of the long bones in children than are the broad bands at the diaphyseal ends. The former are believed to result from periods of cessation of growth, illness, rickets or hypervitaminosis D. Sontag and Comstock believe that they have observed these lines also, after a period of accelerated growth. They present diagrams showing the occurrence of striae in the long bones of a set of identical triplets. They have projected these striae so as to determine as closely as possible the period during which they were formed. In order to study their possible causes they have included in the diagrams data regarding such factors as height, weight, increments of height and weight, season

of the year, illness and entry into school. While there was some similarity in the occurrence of striae in these children, there were enough differences to indicate that the hereditary factor is not the only one, if indeed it is a factor at all, in the formation of the striae. They suggest that such factors as illness, periods of retarded growth in height and weight, increased intake of vitamins and emotional disturbances may have played a part in the formation of striae in the long bones of these triplets.—*R. S. Bromer.*

Froehner, Max. Osteomalazie durch einheimische Sprue. (Osteomalacia in endemic sprue.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, June, 1938, *57*, 575–582.

While the diagnosis of osteomalacia is not difficult with the roentgen examination, the cause of the osteomalacia often presents a serious problem. The concept of primary osteomalacia should be restricted as much as possible. Causes of secondary osteomalacia are the puerperium, endocrine disorders (hyperthyroidism) and, more often than is commonly believed, endemic sprue. The author reports the case of a woman, aged forty-six, with multiple spontaneous fractures, a pernicious anemia type of blood picture and bowel disturbances. The roentgen studies showed an extensive osteoporosis with a mesh-like spongiosa, thin trabeculae and a narrow cortex of the long bones. There was little or no callus at the fracture sites in the ulna, ribs, pelvis, or femur. Although the gastrointestinal symptoms were not outstanding, faulty intestinal absorption was shown by the flat blood sugar curve and the vitamin C tolerance test. The typical fatty stools appeared only after the commencement of liver therapy. Marked improvement with disappearance of the bone pain and healing of the fractures followed intensive vitamin D therapy and large quantities of calcium by mouth.

This disease is regarded as identical with Herter-Heubner's celiac disease of children.—*W. A. Evans, Jr.*

Pohl, R. Arthropathia Psoriatica. (Psoriatic arthropathy.) *Röntgenpraxis*, Dec., 1937, *9*, 825–828.

It has been known for centuries that there is a relationship between psoriasis and certain joint diseases. The roentgenologic method made it possible to study the various phases of the joint affection. It is a rare disease. It probably occurs in less than 1 per cent of all psoriasis patients. It occurs mainly in men and the skin lesions are usually atypical when arthropathy is present, the palms and soles being commonly involved and the involvement being exudative or pustulous.

The joint disease represents a variable picture from mild rheumatoid to severe ulcerative joint processes with more or less complete disappearance of entire bones. Fixations and bony ankylosis have been reported. According to reported cases the involvement of the small joints of the fingers and toes is more common than of the larger joints of the hands and feet.

There have been early cases described where the roentgenologic appearance was normal. From this Wohl concluded that, in contradistinction to osteoarthrosis and neuropathic arthropathy, the primary seat of the disease is the capsular structure. The first roentgenologic sign is the atrophy of the bone. Aside from the acute forms with erosion of the bone trabeculae, various forms of transitions into the chronic forms are found with thinning of the compact substance, diminished number of trabeculae and in more advanced stages areas of sclerosis.

Not uncommonly destructive joint processes occur in the early stages with narrowing of the joint spaces and mushroom or funnel shaped defects at the bone ends. These defects may increase in size rapidly and entire bones may disappear.

In later stages, areas of new bone or cartilage production may be associated with the destructive changes.

The severe destructive forms commonly terminate in ankylosis and the resulting deformities incapacitate the patient.

There is no question that there is a pathogenic relationship between the joint disease and the psoriasis, but the etiology is not yet established. Disturbance of the vegetative nervous system due to an infectious agent, intoxication or a constitutionally abnormal anlage with secondary intrinsic or extrinsic noxious agents are the most important hypotheses to explain the changes.—*Eugene Freedman.*

Holldack, Frank. Zur Frage der seltenen knochen-knorpelwachstumsstörungen. (Some rare growth disturbances of bone and cartilage.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1938, *58*, 1–18.

Two unusual cases are described in detail

with numerous illustrations showing extensive skeletal disorders. One is believed to be a chondrodysplasia which is defined as a congenital disease of the skeleton characterized by irregular and delayed ossification of the intermediate cartilage. At the same time osteocartilaginous tumors occur in the long bones, especially in the metaphyses, and they may be subperiosteal or intramedullary. The epiphyses tend to remain cartilaginous with irregular ossification which is less than one would expect for the patient's age. The author objects to the separation of the unilateral type known as Ollier's disease and complains of the multiplicity of names used in the literature. The most common synonyms are chondromatosis and dyschondroplasia. In the past too many separate entities have been described and the manifold character of the disease has been lost sight of.

The second case exhibited no disturbance in growth, but the epiphyses showed a peculiar irregularity in outline and an irregular form of ossification. Because of the normal growth process dyschondroplasia is excluded as a diagnosis and the author chooses the term chondrodystrophy. The usual type of chondrodystrophy described in the literature, however, is the dwarf with short extremities in relation to the trunk or Morquio's type in which there is disturbed enchondral growth of the epiphyses in the spine. Whether these two types are related, distinct, or identical has been a matter of much dispute. Other types are also described from the world literature and their interrelationship examined.—*W. A. Evans, Jr.*

Mouchet, A. L'épine du premier métatarsien. (The spine of the first metatarsal.) *J. de radiol. et d'électrol.*, June, 1938, *22*, 275–277.

Ledoux-Lebard has previously described an anomaly of the external angle of the articulating surface of the first metatarsal bone. The present author found this anomaly in 30 per cent of routine roentgenograms and states that it is not pathological. An exostosis may occur at this site.—*M. L. Sussman.*

Stehr, L. Die ulnar-volare Bajonetthand als typische Fehlbildung bei Chondrodysplasien. (The ulnar-volar bayonet hand as a typical malformation in chondrodysplasia.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, June, 1938, *57*, 587–604.

Malformations of the forearm occur almost always in the distal portion and are most often part of a general skeletal defect either exostosis cartilaginea multiplex or chondromatosis. This is in contrast to the malformations of the hands and feet which are much more varied and complex. Multiple cartilaginous exostoses and chondrodystrophy are probably always inheritable either in a dominant or recessive manner, although this is not always demonstrable. Subjects may have very extensive deformities of this sort which do not come to medical observation unless there is a spontaneous fracture, a bursitis in the region of an exostosis, or limitation of function produced by a large deformity, or they may be discovered only incidentally to some unrelated complaint.

A large proportion of chondrodystrophic children are born dead or die soon after birth.

Chondrodysplasia may assume quite different forms at different ages and in different parts of the skeleton. A close relation exists between multiple exostoses and multiple chondromas and there are many cases in the literature showing both disorders. The differentiation between an exostosis as part of a general skeletal deformity and as a true blastoma is simpler than the corresponding differentiation with the chondromas. It is more important with the latter, however, as the chondroma is much more liable to malignant degeneration than the osteoma. The generalized character of the disorder may be revealed by the shortening of the ulna at the wrist. The fact that the lower ulnar epiphysis appears much later than the radial plays an important rôle in accounting for the fact that the shortening occurs almost always in the ulna.

Madelung's deformity is a rare skeletal deformity which is the mirror image of the deformity seen in chondrodysplasia in that the radius is shorter than the ulna which extends beyond the wrist joint. This deformity occurs as the result of a disturbance in epiphyseal growth during severe rickets, infection, or other causes. Associated skeletal deformities are exceptional and a hereditary tendency has not been demonstrated. The differentiation of these two types of deformity is important because they have different causes and significance.—*W. A. Evans, Jr.*

Löhr, R., and Hellpap, W. Der Kniegelenkspalt im Röntgenbild. (The roentgen appearance of the knee joint space.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1938, *58*, 45–56.

One often finds differences between the

width of the joint space at the medial and lateral aspects of the knee not only in cases of recent or old trauma, but also in cases with no pain or disability at all. The internal space often appears narrower than the external, but occasionally the reverse is true. The normal spacing between the bony surfaces measures 4–8 mm. The cartilage overlying the bony surfaces makes up the space, but does not cast a shadow. The true joint space between the cartilaginous surfaces is of capillary thickness and may be shown under favorable conditions by positive or negative contrast substances. Dittmann observed the true space with the proper direction of the ray and especially in cases of arthritis deformans. Pannewitz also observed this and attributed it to a pathological increase in density of the cartilage. Grashey cast doubt on this explanation and reported seeing the space in normal knees, especially in children. Hippe and Hähle studied 3,000 roentgenograms and observed the spacing only in the knee or shoulder joint. In all of the shoulders, arthritis deformans was present while in the knee joint 25 cases had arthrosis deformans and 5 were normal. The authors studied 642 films of the knee and observed the true spacing only twice, both at the medial aspect, one a normal knee and one with severe arthritic changes.

The older literature indicated that an increase in the cartilage spacing was a sign of a locked meniscus, others maintained that a meniscus injury led to narrowing of the cartilage on that side. Injuries to the collateral ligaments may lead to an increased space on the affected side. Cartilage degeneration usually affects both sides.

The angle of the projected ray when varied in a sagittal plane does not influence the apparent width of the joint space. A slight change may occur at the medial aspect due to the changing contour of the tibial condyle, but the width will remain constant if the same point on the tibia is used for measurement.

Exposures made of both knees in forced abduction and adduction may reveal an unusually wide spacing and thus indicate an injured collateral ligament in this area.

The authors have studied the films in a group of 36 cases with internal injury of the knee before and after operation, and conclude that a difference in the cartilage spacing at the internal and external aspects is most often due to lesions of the collateral ligaments and only rarely to swelling and thickening of an injured meniscus alone.

From a study of 26 cases of effusion into the joint, they conclude that a recent effusion is not a cause of widening of the joint space. A long-standing effusion may lead to stretching of the collateral ligaments and production of an unsteady knee with widening of the space on that account.

Differences in the internal and external spacing may exist in normal knees and amount to 2–3 mm. In 642 knees the medial space was narrower than the lateral in 81, but in 45 of the latter there were arthritic changes which may have produced degeneration of cartilage.

Following fractures about the knee joint the spacing may be widened or narrowed, depending upon the final relations of the structures within the joint.—*W. A. Evans, Jr.*

Davis, David B., and King, J. Cash. Cervical rib in early life. *Am. J. Dis. Child.*, Oct., 1938, *56*, 744–755.

The cases of 3 children with cervical rib which produced symptoms are reported. The incidence of cervical ribs which produce symptoms, Davis and King believe, is greater than is generally known. The most common symptom is tumor of the neck. Other symptoms may be divided into those of vascular and those of nervous origin. Interference with circulation is brought about chiefly by compression of the subclavian artery, either by the cervical rib itself, as the artery arches over it, or by the scalenus anticus muscle. Instances of pressure on the subclavian vein which produced aneurysm have been reported. Thrombosis of the vessels at the site of obstruction have been known to occur. The radial pulse may be diminished in volume or may be completely obliterated. In those cases in which the radial pulse is normal under ordinary conditions, if the arm on the affected side is raised over the head and the head is turned sharply to the opposite side, the pulse may be obliterated. This is known as the Halsted test. Edema of the neck has been a prominent symptom in 2 of their cases and is probably due to pressure on the subclavian vein.

Symptoms of nervous origin such as pain, atrophy and sensory disturbances, are attributed to pressure on the brachial plexus. The pain may be dull and aching after a long day's work or play, or it may be sharp and knifelike when brought on by sudden turning of the head

or shoulder. It is most commonly felt along the course of the ulnar nerve but may be felt along the distribution of the entire brachial plexus. Atrophy is a late manifestation and may be limited to the intrinsic muscles of the hand or may involve any or all the muscles of the shoulder girdle, the arm, the forearm and the hand. Torticollis, or wryneck, is a frequent and prominent symptom of cervical rib in children. It is spasmodic and is caused by pressure on the spinal accessory nerve. The association of Horner's syndrome with cervical rib has been described. Symptoms of pressure involving the vagus and the recurrent laryngeal nerves are other rare complications.

Oblique roentgenograms of the neck and the upper part of the chest taken with the rays directed upward, laterally and posteriorly through the seventh cervical vertebra will demonstrate more clearly the actual proportions of the rib. The incidence of cervical rib in the 1,000 consecutive roentgenograms reviewed by the authors was 1.2 per cent, and because of the great discrepancy in the incidence given by previous writers and that which occurred in their series they present reproductions of the roentgenograms in 12 cases which were found. They noted that every patient with cervical rib had a long neck and a hyposthenic thorax. There was also a marked variation in the size and contour of the anterior root of the transverse process of the seventh cervical vertebra. In many instances it reached such proportions that it was difficult to differentiate it from a rudimentary rib.

In the interpretation of roentgenograms of children under five years of age, the presence of a separate piece of bone adjacent to the transverse process of the seventh cervical vertebra should be recognized as a center of ossification which is a potential precursor of a cervical rib.—*R. S. Bromer.*

Guerin, R., and Lachapele, A. P. Platybrachyspondylie. (Platybrachyspondyly.) *Bull. et mém. Soc. d'électro-radiol. méd. de France*, April, 1938, *26*, 282–290.

Platybrachyspondyly can be classified as follows: (1) platyspondyly, a term used by Putti to describe a widened vertebra. The term has erroneously been used to imply a flattened vertebra; (2) brachyspondyly—vertebra is diminished in height. The discs are very high. The commonest example is osteochondritis or vertebra plana of Calvé; (3) platybrachyspondyly—vertebra widened and diminished in height, discs increased in height: (*a*) in one body—particularly affecting the 5th lumbar in cases of spina bifida; (*b*) several bodies, associated with multiple anomalies throughout the spine; (*c*) generalized. This is the rarest form. —*M. L. Sussman.*

Pokorny, L. Wirbelsäulenveränderungen nach Tetanus. (Vertebral changes after tetanus.) *Röntgenpraxis*, Dec., 1937, *9*, 813–818.

After the World War there were scattered reports in the literature concerning changes in the vertebrae after tetanus, consisting of compression fractures. Various authors found this complication between 20 to 84 per cent of the patients who had suffered from tetanus.

The author reports the histories of a ten and an eleven year old boy in whom multiple compression fractures of the dorsal vertebrae were found several weeks after the onset of a tetanus infection. The intervertebral spaces were well maintained and there was no evidence of shadows to suggest paravertebral abscesses.

Due to the contraction of the flexor and extensor muscles of the trunk during the convulsive attack the vertebral bodies are exposed to an unusually great pressure. This process is repeated during each attack of convulsion. In addition, the long standing contractions compress the blood vessels of the muscles. The neighboring structures participate in the impairment of circulation and the nutrition as well as the resistance of the vertebral bodies is thereby diminished, facilitating the action of the increased pressure.—*Eugene Freedman.*

Marill, F. G., Raynaud, R., and Huguenin, A. Remarques à propos d'un cancer vertébral. (Vertebral cancer.) *Bull. et mém. Soc. d'électro-radiol. méd. de France*, March, 1938, *26*, 170–174.

After correlation between the roentgenographic examination of a patient and the postmortem pathologic and roentgen examinations of his spine, the following conclusions are reached:

1. In spite of marked osteoclastic metastasis in a vertebral body, there may be no collapse.

2. The discs above and below the lesion remain intact.

3. The frontal views are not as valuable as lateral roentgenograms in the demonstration of metastases.

4. Roentgenogram of the dry specimen re-

veals more marked lesions than does the examination of the living body. It follows that in general the lesions present are apt to be greater than is shown on roentgenograms of the living subject.

5. Metastasis may be present even if the roentgen examination of the living subject fails to reveal them.—*M. L. Sussman.*

Müller, Wolfgang, and Pich, Gertraude. Beitrag zur Differentialdiagnose primärer und sekundärer Wirbelgewächse. (The differential diagnosis of primary and secondary neoplasm of the spine.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, August, 1938, *58*, 136–146.

The case is reported of a man, aged eighty, with a symptomless carcinoma of the stomach and a solitary metastasis to the lumbar spine which was of such size as to lead to compression of the cord and death. The metastasis was an osteoblastic mass with a radial arrangement of the trabeculae which led to an ante-mortem diagnosis of a primary sarcoma in spite of the advanced age of the patient. Bone metastases from primary tumors of the gastrointestinal tract are rare (1–2 per cent according to the literature) although Borrmann believed the low incidence was due to incomplete pathological examination and was able to demonstrate spinal metastases in 20 per cent of 39 cases of gastric carcinoma. On the other hand, primary sarcoma of the spine is rare when compared with its occurrence in the long bones. Both primary and secondary growths of the spine may be purely destructive or lead to dense bone formation. The differential diagnosis as in this case may be very difficult.—*W. A. Evans, Jr.*

Schulze, Konrad. Ein Beitrag zur Frage der Verlagerung von Bandscheibengewebe. (Additional information on the question of displacement of the intervertebral disc.) *Röntgenpraxis*, July, 1937, *9*, 461–465.

Schmorl's pathologic anatomic and roentgenologic investigations greatly enlarged our knowledge concerning the disease process in the disc. The origin and the roentgenologic appearance of the so-called "cartilage node" are well known by now. It is caused by the penetration of the disc into congenital or traumatic fissures of the cartilaginous plate and occurs in the region of the nucleus pulposus at the central portion of the vertebral end-plate. Herniation of the disc may also be secondary to a primary disease of the vertebral bodies, like osteoporosis, osteitis deformans, and other conditions. Then disease process decreases the resistance of the vertebral bodies and the cartilage burrows its way into them.

In addition to the central location, the displacement of the cartilage may occur on the peripheral portions of the vertebral end-plate also, producing the so-called "separated margins." The upper margins in the lumbar region are most commonly involved. Janker called them "persistent vertebral epiphyses" while Schmorl thought at first that they were due to fractures but later demonstrated that this type of separation is caused by a displacement of the disc just as in "cartilage nodes." The vertebral body possesses an upper and a lower end-plate which is perforated in a sieve-like fashion. Over it lies the cartilage plate which is connected with the disc by fibrous cartilage. During childhood the vertebral margins show step-like defects which are filled with hyalin cartilage but later ossify to form the compact marginal ring. The cartilage plate extends only to the medial border of this ring. This peculiar construction favors small fissures in the cartilaginous end-plate near the marginal ring, and under the influence of the elastic force of the intact nucleus, the disc may herniate into the area between the end-plate and the compact marginal ring.

The author shows an illustration of a case where in a man, aged twenty-seven, a large defect was found on the upper anterior margin of the second lumbar vertebra with arch-like, somewhat fuzzy but sclerotic margins. Within this defect a triangular structure of bony density was seen, corresponding to the upper marginal ring. The anterior upper border of the first lumbar vertebra was also involved and showed a downward convex area of sclerosis at its anterior upper border.

In addition to the peculiar changes of the first and second lumbar vertebrae, the eleventh and twelfth dorsal vertebral bodies showed wedge-shaped deformities and irregularities of the upper and lower end-plates, typical of juvenile kyphosis.

The author concludes that the changes of the first and second lumbar vertebrae represent a rare and atypical localization of a prolapse of the intervertebral disc, the prolapse occurring at the anterior portion of the upper end-plate of the first lumbar vertebra, producing a separation of the upper anterior margin and a

marked destruction associated with reactive condensation of the spongiosa around the separated margin.—*Eugene Freedman.*

Oppenheimer, Albert. The apophyseal intervertebral articulations, roentgenologically considered. *Radiology*, June, 1938, *30*, 724–741.

This article is an excellent survey of the disease of the articulating facets of the spine. The technique of the examination is given in detail and the positioning of the patient varies, depending upon the portion of the spine being examined. The plane of the facets of the cervical region is at right angles to the sagittal plane of the body, the dorsal facets form an angle of 70 degrees to this plane and the lumbar facets form an angle of very nearly 45 degrees. The importance of accurately positioning the patient is stressed.

There are three main types of pathological change:

(a) Atrophic spondylarthritis; acute, chronic and ankylopoietic;
(b) Hypertrophic spondylarthritis; primary or consecutive upon abnormal mechanical stress;
(c) Secondary involvement by various affectations of the vertebral bodies.

The affectations of the articulating cartilage, as made evident by narrowing of the apophyseal joint space, is the essential lesion in the different types of chronic spondylarthritis. Calcification and ossification of the ligaments is not pathognomonic of any particular disease.

The author prepared a classification as follows:

(a) Spondylitis being an inflammatory disease of the spine, especially of the vertebral bodies, either rarefying, as in tuberculosis, or hypertrophic as in low grade infection and in mechanical irritation resulting, for example, from thinning of the discs.
(b) Spondylarthritis, being an inflammation of the spinal joints, the apophyseal intervertebral articulations, there being no other true joints in the spine.
(c) Spondylosis ossificans ligamentosa, being determined by ossification of the spinal ligaments, especially in the absence of changes in the vertebral bodies, intervertebral discs and apophyseal articulations.

The author has beautifully illustrated the article with examples of the different types of arthritis involving the articulating facets. There is also an excellent chart giving the classification according to the roentgenological aspects.—*J. H. Harris.*

ROENTGEN AND RADIUM THERAPY

Lüdin, Max. 20 Jahre Röntgentherapie. (Twenty years' roentgen therapy.) *Strahlentherapie*, 1937, *60*, 483–504.

The author reviews his work at the Roentgen Institute of the University of Basel for the past twenty years. From 1916 to 1935, 2,908 cases were irradiated. He considers particularly 1,665 of these. He does not give statistical data but some comments on the results of treatment in the different groups.

There were 457 cases of tuberculous lymphoma of the neck. The results of roentgen treatment are very good in this group of cases. It must be given carefully with small doses. With heavy metal filtration the severe skin injuries of former days are not seen. After irradiation tubercle bacilli cannot be demonstrated in the glands.

There were 113 cases of peritoneal tuberculosis. Roentgen irradiation is the sovereign remedy in these cases. The results were very good in 106 of his cases. Only 7 cases were lost and in these there was in addition to the peritoneal tuberculosis an active pulmonary tuberculosis. Roentgen irradiation should not be used in such cases.

There were 197 cases of other forms of tuberculosis. Tuberculosis of tendon sheaths is favorably affected by irradiation and the effects are also good in tuberculous dacrocystitis. Irradiation should be used for after-treatment in operation for tuberculous otitis. The author treated only 12 cases of pulmonary tuberculosis with irradiation, with poor results in all. Most of the patients at his clinic had pneumonic and exudative forms of tuberculosis which are unfavorable for roentgen treatment.

The beginning results were good in the 29 cases of malignant goiter. In most cases there was no local recurrence but 28 of the patients died within four years of metastases; only 1 patient survived the treatment for more than eight years. The treatment was used in 112 cases of Basedow's disease, toxic adenoma and

hyperthyreosis. The effect on the subjective symptoms was good, basal metabolism returned to normal and the patients were able to return to work. The treatment requires a long time.

The results were excellent in 27 cases of tumor of the hypophysis; this is the treatment of choice. Irradiation brought about only temporary improvement in the treatment of the troublesome sialorrhea in late Parkinsonism; 12 cases were treated, with permanent recovery in none.

The 5 cases of hypertrophy of the prostate were too few to permit of definite judgment in regard to results. The difficulty of micturition was considerably improved. The results vary in arthritis deformans. Among the author's 117 cases, the fresh cases with swelling, pain and limitation of movement seemed to respond best. The results were good in all the 18 cases of subacromial or subdeltoid calcareous bursitis. The results were poor in all except 1 of 63 cases of carcinoma of the bronchi and lungs. The results were also poor in actinomycosis of the lungs and pleura; only 1 of 4 cases was cured. The results were surprisingly good in many of his 40 cases of bronchial asthma, though most of them were not fresh cases, in which this treatment is supposed to be most effective.

The treatment seemed to have a good effect on the pain in the 50 cases of neuralgia, but often the results were not better than those of other methods of physiotherapy. The treatment had no effect in the 4 cases of multiple sclerosis. In 7 cases of syringomyelia there was a marked improvement in the sensory and motor disturbances, though a part of this may have been spontaneous. In all of 18 cases of herpes zoster there was a good effect on the pain. The results were remarkably good in the 130 cases of erysipelas. Pain was controlled and the course of the disease shortened in 10 cases of thrombophlebitis. In 11 cases of polycythemia vera the blood findings became normal and the general condition was greatly improved. Clinical cure was brought about in 4 cases of essential thrombopenia. Roentgen treatment is the only one that gives any hope of success in chronic myeloid leukemia. In the author's 42 cases he irradiated the spleen carefully till erythrocytes and hemoglobin were normal and then stopped even though the spleen was still enlarged and the number of leukocytes not yet normal. In this way the patients can be kept in good general condition for years. Regular blood control during the treatment is very important. He believes life is prolonged and certainly the patients are made more comfortable and more able to work while they do live. One patient thirty-seven years of age lived ten years and another eleven years. In 24 cases of chronic lymphatic leukemia, careful irradiation of the spleen and gland packets gave good results. One patient of fifty is in good condition five years after treatment was begun.

Roentgen irradiation had no effect in 9 cases of acute leukemia, 3 of the lymphatic and 6 of the myeloblastic form. The results were good in 12 cases of aleukemic lymphadenosis. On the contrary, they were poor in 3 cases of aleukemic myelosis. Treatment was unsuccessful in 2 cases of tuberculosis of the spleen. In 61 cases of lymphogranulomatosis the results were very good. Massive doses should not be used. The longest survivals were ten and twelve years.

In melanosarcoma (11 cases) the prospects are very poor. In lymphosarcoma (17 cases) the results are generally excellent at first but recurrence is frequent. In round and spindle cell sarcoma (56 cases) the prognosis is not too bad. He cites and illustrates a cured round cell sarcoma of the foot, 1 of the nose, a spindle cell sarcoma with cure for five years and death of apoplexy, a case of small round cell sarcoma in which the patient is living after five years and a case of large round cell sarcoma of the mediastinum in which the patient lived eleven years and died of suicide. Among 7 children with retinal glioma, 6 died during the treatment.

It should be possible now to avoid skin injuries with careful technique. Roentgen treatment is apt to give better results in hospitalized than in ambulant patients as they are less influenced by friends and relatives. He advises giving up the term "roentgen sickness" as many transitory ills due to other causes are attributed to it.—*Audrey G. Morgan.*

Kruchen, C. Spätschädigungen durch Röntgenstrahlen. (Late injuries from roentgen rays.) *Strahlentherapie*, 1937, *60*, 466–475.

The author discusses the local injuries that sometimes appear years after a roentgen irradiation though there was no apparent injury at the time of the treatment. Two cases are described illustrating this type of injury.

The first patient was a man of sixty-five who was irradiated twenty years ago during the war for thyroid disease. Some years after the irra-

diation an atrophic skin area with some telangiectases developed at the site of the irradiation; it was about the size of the palm of the hand. In recent years small eruptions had developed in the peripheral part of this area and some of them had ulcerated. Recently difficulty in swallowing had developed. Roentgen examination showed the entrance to the esophagus contracted at the level of the cricoid cartilage. There was a tumor on the posterior wall which proved on examination of an excised piece to be a carcinoma.

The question of whether the carcinoma was caused by the irradiation is discussed. It seems probable that it was. It is to be remembered that there is a venous plexus on the posterior wall of the hypopharynx at about the level of the irradiation that is very sensitive to the action of the rays.

The second patient was a man of thirty-one who was operated on in 1929 for a right inguinal hernia. In December, 1931, a tumor developed at the site of the operation. It was excised and proved to be a spindle cell sarcoma strongly adherent to the vessels. As fresh signs of tumor appeared in the spring of 1932, he was given roentgen irradiations in the right inguinal region. From July 21 to August 9 a total of 2,560 r was given in individual doses of about ¼ H.E.D. and from October 25 to November 2, 1,080 r. After this treatment the patient was able to go to work again but about a year later an area of wooden hardness about 20×20 cm. in size appeared in the irradiated region. The skin was slightly brown and there were some telangiectases. About a year later there was a large deep ulcer immediately below Poupart's ligament. Up to July 7, 1936, the ulcer increased in size. On October 10, 1936, there were ulcer masses the size of plums in the ulcerated scar tissue. The leg was shortened from extension of the sarcoma to the hip and ilium.

Some of these cases of late injury are caused by exogenous factors, such as pressure, trauma, operation, etc.; others by endogenous factors, such as endocrine disturbances, tuberculosis, diabetes, etc. But even these do not account for all such injuries. There must be local biological differences in sensitiveness to irradiation. Apparently the veins are very sensitive to irradiation and this sensitiveness varies in different individuals for reasons that are not as yet very well understood.—*Audrey G. Morgan.*

Kautzky, A. Zur Frage der atypischen Hautreaktionen nach Röntgenbestrahlung. (Atypical skin reactions after roentgen irradiation.) *Strahlentherapie*, 1937, *60*, 439–443.

Most of the atypical skin reactions seen after irradiation are injuries from cumulation. Generally they are late injuries, though they may occur comparatively early. The author describes briefly 4 such cases that he has seen recently in the course of irradiation.

The first was in a woman of sixty who had a total extirpation performed in November, 1934, for carcinoma of the cervix. This was followed by prophylactic irradiation. The technique was as follows: 180 kv., 4 ma., with a focus-skin distance of 40 cm. and a filter of 0.5 mm. copper and 1 mm. aluminum giving a r/min. influx of 16 r free-air with a half-value layer of 0.9 mm. copper. Five fields 10×15 cm. in size were irradiated with a cycle of 500 r each, eight days later with 300 r each, ten days later with 200 r each and still ten days later with 100 r each; that is, a total of 1,100 r to each field. Five days after the close of the treatment a rash appeared on both parasacral fields and the right inguinal field. The dermatologist said it was an exacerbation of an acne rosacea. There was a slight acne on the nose which had not been noticed. It took three weeks for the eruption to recede. The acne on the face did not grow worse during this period but on the contrary improved. She was given two more series of irradiations six and nine months later without any complication.

The second patient was a woman of fifty-six who had a hyperthyroid condition and also a slight diabetes mellitus. Basal metabolism was only moderately increased. During the treatment after she had had 150 r three times on four fields 8×10 cm. at intervals of a week she appeared with an urticaria. There were not only spots on the limbs and trunk but the irradiated fields were entirely covered with the eruption. The patient said she frequently had nettle-rash, particularly after eating fruit. The eruption completely disappeared in a week. In this case a small dosage of radiation had caused a considerable increase in the allergic reaction in the irradiated area.

But even smaller doses may cause a reaction. The third was in a girl of seventeen who had hemolytic icterus. Three fields over the spleen each 10×15 cm. in size had been irradiated with

50 r each. After about three weeks all the fields showed a moderately intense exanthem which had already passed into a slight pigmentation at the beginning of the second series of irradiations. The dose in this case was barely 10 per cent of a skin erythema dose.

The fourth case was in a woman of sixty with malignant goiter who was given 4,000 r fractionally in the course of twenty-four days. Infection of a scratch on the skin had been caused by lack of cleanliness and suppuration of the whole field 10×10 cm. in area took place. But two weeks later the whole surface was healed and the roentgen eruption had disappeared. This case shows some resemblance to the sensitizations that can be caused chemically, for instance by barbituric acid derivatives.

The course of most of these eruptions is mild. But they add another possibly injurious factor to the course of the biological reaction. Possibly the observation of such cases may show a way of bringing about a more rapid course of the reaction with smaller doses.—*Audrey G. Morgan.*

Gauss, C. J. Hat sich unsere weitgehende Ablehnung der operativen Therapie bei Myomen und Präklimakterischen Metropathien praktisch bewährt? (Is the extensive rejection of operative treatment of myomas and preclimacteric metropathies justified by practical results?) *Strahlentherapie*, 1937, *60*, 401–421.

The extent to which myomas and preclimacteric metropathies can be treated without operation has not as yet been answered satisfactorily. In order to make a contribution to its solution the author considers 1,048 cases treated at the Würzburg clinic from July 1, 1923, to December 31, 1928, 597 of myomas and 451 of preclimacteric metropathies. So far as possible and unless there were decided indications for operation, these were treated by irradiation. Of the total number 68 were treated by simple curettage, 887 by irradiation and 93 by operation. All of the patients treated by operation had myomas; all of the preclimacteric metropathies could be treated by curettage or irradiation. Of the total number therefore only 8.9 per cent had to be operated on and it is probable that this number could have been restricted still further. Irradiation could be used in 91 per cent.

Tables are given showing the details of the results. There were no complications among the cases treated with roentgen rays and only 3(1.7 per cent) among those treated with radium—2 cases of thrombophlebitis and 1 of infection. But among the operated cases there was a morbidity of 10.8 per cent. There were no deaths among the 887 cases treated by irradiation while among the 93 treated by operation there were 4 deaths. The much higher morbidity and mortality among the operated cases seems to show that rejection of operation in favor of irradiation is entirely justified. The results as to later signs of the menopause were also better among the irradiated cases. The author gives a questionnaire which he thinks it advisable to submit to all patients after operation or irradiation showing what unpleasant symptoms they have had. This is the only way to determine whether operation or irradiation gives the best results from this point of view. So far the results from his own and other clinics have been in favor of irradiation.

He advises telling patients of the results of operation and irradiation and giving them the opportunity to choose unless there is some decided reason requiring one or the other method of treatment in that particular case. If they are allowed to choose it lessens the chances of psychic symptoms of the menopause after treatment. But unless there are decided reasons to the contrary he prefers irradiation.—*Audrey G. Morgan.*

Stühmer, A. Die dreigeteilte Bestrahlungsserie als Regel in der Röntgenbehandlung der Hautkrankheiten. (The three-treatment series as a rule in the roentgen treatment of skin diseases.) *Strahlentherapie*, 1937, *60*, 706–711.

The correct dosage in skin diseases has been determined empirically and little has been known about its biological action. Hans Meyer was the first to introduce the idea of a divided dose in the treatment of skin diseases. He divided the normal dose into three individual treatments given at eight to ten day intervals, the full dose being given within three weeks. The author has used this scheme but finds that 20 per cent of the full dose given three times at intervals of ten days is sufficient to bring about the desired effect. Taking into consideration the time factor, this is only about 50 per cent of a full dose, but it seems to have as good an effect as the 30 per cent series in eczema, psoriasis, etc.

An attempt is made to explain this effect by representing the divided irradiation graphical-

ly. Each treatment causes a wave of erythema or stimulation of the cells. As the wave of stimulation rises and falls it is desirable to give the succeeding irradiations at a favorable time in the wave of the preceding one. According to Meyer's series, the second stimulation comes at the beginning of the rise after the first one and the third at the crest of the wave after the second. It seems probable that this method of treatment is better adapted to the biological processes in the cells than a single large irradiation, and that therefore a greater effect is obtained with a given amount of radiation.

It is desirable in skin diseases to use as little irradiation as possible. With progress in roentgen therapy more will probably be learned about the rhythm of biological processes in the cells and it will be possible to adapt the stimuli of roentgen treatments to these rhythmical processes more perfectly.—*Audrey G. Morgan.*

Kreiner, Adolf. Methodisches zur Abgrenzung und Festlegung von Hautfeldern bei Anwendung der Grenzstrahlen. (Method of demarcating and making a permanent record of the skin fields in using grenz rays.) *Strahlentherapie*, 1937, *60*, 619–630.

The author who works in the sanatorium for lupus patients at Giessen discusses the value and limitations of grenz-ray treatment. Some workers are ardent advocates of this method and others reject it as practically useless. He thinks it extremely valuable, though he admits it has its dangers.

An apparatus for adjusting the rays accurately to the part of the skin to be treated and of protecting the very delicate Lindemann window is described in detail and illustrated. As these patients often have to be treated repeatedly over long periods it is important to know just what dosage has been given and over what areas. It is very inaccurate to simply write in the history sheet, "irradiated on the forehead, the cheek," etc. The field must be known accurately in order to be sure of the exact dosage given over a certain area. Therefore the author takes photographs of the patient on which the irradiated field is inscribed exactly. This photo graph is accompanied by a history sheet on which the exact amounts and the dates on which they were given are registered. The use of these accurate methods will make grenz treatment of lupus less dangerous and more effective.—*Audrey G. Morgan.*

von Wieser, W. Zur Röntgentherapie der Hyperthyreose. (Roentgen treatment of hyperthyreoses.) *Strahlentherapie*, 1937, *60*, 712–715.

The maximum of successful results in the roentgen treatment of hyperthyreoses is about 70 per cent, the average not more than 60 per cent. Some of these failures are due to the fact that dosage is not sufficiently individualized but a routine scheme of treatment is adopted. But this applies to only a relatively small number of cases. The real reason for the failure in the majority of cases is that the hyperthyroid condition is not primary but secondary to some other condition that does not respond to irradiation of the thyroid.

Pal and Borak have described cases of hyperthyroidism caused by cerebral disturbances in the vegetative nerve centers. The author saw a particularly striking case of this kind in a patient who had had lethargic encephalitis followed by hyperthyroidism. The patient did not respond to irradiation of the thyroid but basal metabolism returned to normal promptly when the vegetative centers in the brain were irradiated.

Aron several years ago described a form of functional disturbance of the hypophysis which caused symptoms similar to those of hyperthyroidism. In another group of cases the primary cause of the hyperthyroidism is a toxic form of infectious disease, generally tuberculosis. These cases usually respond to roentgen treatment, however, if small enough doses are used and the thymus is also irradiated, as it often is in the treatment of hyperthyroidism. With this method of treatment the lungs are also given some irradiation. The doses usually used in the irradiation of the thyroid are injurious, however, in tuberculosis so it is important to make the differential diagnosis.

In another group of cases the hyperthyreosis is caused by abuse of thyroidin or iodine. This may be brought about by the use of iodized salt. This may happen without the knowledge of the patients, as in orphans' homes. These patients do not respond to irradiation at all but may respond readily to withdrawal of the iodized salt. In these cases the sella is apt to be smaller than normal. This question should be studied further by examining a large number of cases of primary and secondary hyperthyroidism.—*Audrey G. Morgan.*

Branscheid, F. Ueber die Behandlung des Echinococcus cysticus mit Röntgenstrahlen. (Roentgen therapy of echinococcus cysts.) *Röntgenpraxis*, August, 1937, *9*, 552–555.

Many attempts have been made to treat echinococcus cysts of the lungs and liver with roentgen rays, but only a few cases are described where the therapy was followed by the death of the parasites. There is some difficulty in evaluating the therapeutic results because, not uncommonly, the growth of the cysts is slow. It would be necessary to experiment on a large group of animals, one-half of which would be irradiated while the other half would remain unirradiated.

Theoretically, the procedure appears to be logical, because histologically the cyst consists of an inner parenchymatous or embryonal layer and an outer cuticular layer. The fluid is situated within the embryonal layer. The embryonal layer produces, through budding, new parasite heads, and occasionally, through demarcation, daughter cysts. The cuticular layer, consisting of chitin, is radioresistant. But one is obliged to surmise that the embryonal layer is more radiosensitive than the nieghboring tissues, making it possible to kill the embryonal layer with the aid of concentrated roentgen therapy and to prevent the further growth of the cyst. A condition would be thus created which is similar to the spontaneous death of the cyst associated with coagulation necrosis of the embryonal layer. As the fluid would no longer be secreted and the remaining fluid would gradually be absorbed, finally the cyst would contain no more fluid, the cuticular layer would shrink and the cyst collapse.

The author treated a female, aged fifty, who suffered from an echinococcus cyst of the left lung, proved by sputum examination. During the first week of November, 1933, the patient was treated through four fields, each receiving 60 per cent s.e.d. at 190 kv., 4 ma., and 0.5 mm. Cu filtration. The size of the cyst decreased slightly after the therapy but the cough and expectoration did not improve and a second therapeutic course was resorted to in March, 1934. The cyst gradually decreased in size afterward and the expectoration diminished. Finally, in December, 1935, the patient expectorated a large, yellowish mass, which was found to be the cuticulum of the cyst. A subsequent roentgen examination showed no longer the previous spherical structure, only a partial collapse of the left lower lobe. Re-examination in October, 1936, showed only a slight retraction of the left lower thoracic cage, but no other abnormalities, and the patient was clinically well.

The author does not believe that the roentgen therapy killed the cyst, as the symptoms continued after the therapeutic procedures, but surmises that the therapy may have damaged the embryonal layer to such a degree that the cyst eventually died and that the cuticulum, no longer a living substance, became accessible to the expulsory effects of respiration and cough.—*Eugene Freedman.*

Kuhlmann, Bernhard. Zur Prognose der Röntgentherapie der Lungenaktinomykose. (Prognosis of roentgen treatment of actinomycosis of the lungs.) *Strahlentherapie*, 1937, *60*, 476–482.

A few cases of successful treatment of actinomycosis of the lungs by roentgen rays and potassium iodide have been published but failure has been reported in the majority of cases. The author reports a case which shows that good results can be obtained if diagnosis is made early and combined treatment given with roentgen rays, potassium iodide and gold preparations.

His patient was a man of fifty who was an ardent hunter. In 1931 he began to have cough and pain in the right side of the chest. Clinical examination indicated involvement of the right apex. Examination of the sputum did not show tubercle bacilli. Finally actinomyces were found. The patient remembered that he had skinned and dressed a deer that had an actinomyces tumor on its jaw. In September, 1931, he was given the first irradiation over the upper lobe; front and back fields 15×15 cm. in size were irradiated at a distance of 40 cm. with doses of 200 r to each field on four successive days. The same series was repeated after four weeks. The clinical symptoms disappeared and the roentgen picture showed normal conditions.

The patient was well for two years but continued to hunt and expose himself to cold. In October, 1933, he again had cough and pain in the breast. Roentgen examination showed a focus the size of a small apple at the right hilus. Four fields were irradiated with a dose of 200 r, repeated four times. Again there was improvement but in January, 1934, there was swelling of the glands of the right side of the neck and diffuse enlargement of the hilar shadows. Both hilar regions were irradiated. In April, 1934, the

patient grew worse. He had cough, fever, exhaustion, pain in the spinal column and a herpes zoster of the fourth dorsal segment. He was again irradiated and given large doses of potassium iodide and aurodetoxin. Four weeks later the pain in the spinal column and the neurological symptoms had disappeared. He still had cough and bronchiectatic sputum, for which he was given turpentine, dicodid and potassium iodide with excellent results. His general condition improved gradually and in January, 1936, he was completely free of symptoms and the roentgen picture was normal. In July, 1937, there were no pathological findings in the lungs.

This was a severe case of actinomycosis of the lungs lasting from the summer of 1931 to the summer of 1934, with migration of the infection to the hilar glands, pleura, cervical lymph glands and the left posterior spinal nerve roots. Early fractional protracted roentgen treatment brought about complete recovery which has persisted for three years.—*Audrey G. Morgan.*

Doub, Howard P., Hartman, Frank W., and Mitchell, C. Leslie. The immediate and end-results of radiation therapy in certain benign bone tumors. *Radiology*, April, 1938, *30*, 420–436.

The authors review their experience with radiation therapy of benign bone tumors. Four cases of giant cell tumors were treated. Two of the cases became malignant and the patients died. One case was treated after exploration of the tumor and calcification took place; however, a pathological fracture developed. The fourth case was treated after exploratory operation and good results were obtained.

One solitary bone cyst was treated postoperatively and later became malignant.

Two chondromata were treated but with indifferent results.

The authors feel that roentgen therapy and surgery should not be combined in the treatment of giant cell tumors. The increased irritation resulting from such a combination may possibly be a factor in the transformation from a benign tumor to a malignant one.—*J. H. Harris.*

Leddy, Eugene T., and Desjardins, Arthur U. Radiotherapy for tumors of the testis. *Radiology*, Sept., 1938, *31*, 293–298.

In studying 314 patients treated for testicular tumors at the Mayo Clinic it was noted that metastasis to the para-aortic nodes occurred 180 times. This metastasis generally was to the nodes in the celiac axis and usually on the same side as the testicular tumor. Under ordinary circumstances metastasis took place to retroperitoneal nodes, to the "pilot" supraclavicular nodes and to the lungs or other organs in the order named. The inguinal lymph nodes became involved only when the tumor had perforated the capsule of the testicle. Metastasis to the lungs was an uncommon occurrence and was a relatively late complication.

The radiotherapists at the Mayo Clinic feel that the long roentgen waves are just as effective and possibly not so harmful to surrounding structures as the waves generated by 200 kv. (peak). Their plan of treatment is to use four anterior abdominal areas extending from the xiphoid to the pubis and four posterior areas at corresponding levels. The left supraclavicular space is irradiated and also the mediastinum. Each field received about 550 r. This course is repeated in one month, even though metastasis cannot be demonstrated. If the reaction of a metastatic lesion or the microscopic report of the tumor indicates a true adult type of cancer, a third course of treatment is given.

The authors regard irradiation of testicular tumor patients as a palliative agent and not as a curative one. They feel that as an adjunct to surgery, it apparently increases the survival by 13 per cent. The two most important factors that influence prognosis are the type of tumor and the presence or absence of metastasis at the time of treatment.—*J. H. Harris.*

Pickhan, A. Gesichtspunkte zur Strahlenbehandlung des Gebärmutterhalskarzinoms. (Points in the radiotherapy of cancer of the cervix.) *Strahlentherapie*, 1937, *60*, 505–517.

The author discusses the newer methods of distributing the dosage of radiation over a longer time. This takes into account not only the destruction of the malignant cells but also the stimulation of the normal surrounding cells, the object being to increase the tolerance of the protective connective tissue. Irradiation must take into account the biological general disease as well as the local conditions.

He discusses the biological action of roentgen and radium rays and says that Failla in 1933 showed that with the same conditions of use the biological action of roentgen and radium rays is the same.

Statistical tables and graphs are given showing the results of treatment of cancer of the cervix at his hospital from January 1, 1926, to June 30, 1935. A total of 1,536 cases was treated. Among these cases 582 were treated with radiation alone. During the first six months there were 17 deaths, or 3 per cent. Of the others, 452, or 79.2 per cent, were free of recurrence, 65, or 11.3 per cent, improved, and 37, or 6.5 per cent, not improved. About 54 per cent of the patients who survived the primary treatment were free of recurrence after ten years' observation and Group 1 showed 69 per cent cures after ten years.—*Audrey G. Morgan.*

von Wieser, W. Principes fondamentaux de la roentgenthérapie des affections inflammatoires. (Fundamental principles in the roentgen therapy of inflammations.) *J. de radiol. et d'électrol.*, May, 1938, *22*, 209–214.

The following conclusions are reached: There are two possible but quite different methods of influencing an inflammatory process by roentgen irradiation.

1. A direct effect by small doses.

2. An indirect effect by exclusion of the function of the affected organ, using the larger doses that are required for this purpose.

3. A direct influence depending on local and general reactions.

4. Between these there is a reciprocity of action which may be beneficial or not.

5. Dose and dose intervals must be adapted to each individual case. The intervals must be sufficiently large so that reactions can be watched for cumulative effect or lack of effect.

6. Under certain conditions, increased dosage may be necessary even if smaller doses are usually effectual.

A. The stage of the inflammation and the tissue diseased suggests the dosage necessary for a direct effect. A small dose produces a regression. Larger doses increase the process in proportion to the size of the dose. When too large, reaction is lacking. Allergic individuals are sensitive.

B. The indirect effect calls for a dose above the threshold necessary to inhibit the function of the organ, when the latter is not essential to the organism.—*M. L. Sussman.*

Gibert, Paul. La roentgenthérapie des adénoïdites. (Roentgen therapy of adenoiditis.) *J. de radiol. et d'électrol.*, Jan., 1938, *22*, 19–22.

Adenoids may be of importance in youth because of infection or mechanical obstruction. Although they usually atrophy by the eighteenth year, they may remain and may even hypertrophy. While most cases are treated adequately by curettage, even the otolaryngologist agrees that this is not always possible, particularly where the adenoids do not form a conglomerate mass but rather line the pharyngeal wall. Other contraindications are: (1) infancy, under four years; (2) infection. There may be other general states in which avoidance of surgery would be desirable.

The authors have treated about 50 infants with regression often occurring in the second week after two to four treatments.

The factors used were: 1.0 mm. Al, 0.5 mm. Cu; 23 or 30 cm. distance; a field large enough to cover the cervical area from zygomatic arch to clavicle. The large field is insisted upon because of the possibility of other enlarged infected glands. In young infants small doses are used—100 r, two, three or rarely four times bilaterally, i.e., totals of 400, 600 or 800 r spread over fifteen days to three weeks. There is no skin reaction. The doses are considered quite small and it is felt that they may be safely increased with better results.

There is usually regression of the adenoidal tissue but even if there is not, the anti-infection effect of the roentgen rays is of postoperative benefit.—*M. L. Sussman.*

Duhem, Moro, and Montmignaut. La radiothérapie du duexième ganglion sympathique lombaire dans les coxarthries. (Radiotherapy of the second lumbar sympathetic ganglion in arthritis of the hip.) *Presse méd.*, Jan. 29, 1938, *46*, 153–154.

The authors decided to try radiotherapy over the second lumbar ganglion in the treatment of arthritis of the hip because of the following: the various effects obtained in the radiotherapy of the sympathetics reported by Gouin and Bienvenue and also Heinz Langer; and on the vagus by Zimmeru and Chailley Bert; the surgical researches of Leriche; the success reported by Massant following injection of a local anesthetic about the second lumbar sympathetic ganglion (incidentally 10 cc. necessarily diffused, was used).

The cases treated were mostly old and painful and had marked functional impairment. In all cases there were definite roentgen changes—

eroded acetabulum, flattened femoral head and osteophyte formation at the acetabular margins or at the femoral head.

Technique: The reference point is the spinous process of L2, the normal ray falling about 3 cm. to the affected side of the line of the spinous processes. A 10×10 cm. field is used and L1 and L3 are therefore, included. If the treatment is unilateral, a further localization is made with a window in lead rubber; if bilateral, the 10×10 cm. field covers both sides centering on the spinous process of L2. The factors used are 180 to 200 kv., 3 ma., 0.5 mm. Cu, 2.0 mm. Al, 40 cm. distance. A dose is given which is adequate but not so large that it cannot be repeated many times; 150 r per sitting is given, two treatments a week to a total of six. On the whole, the results are satisfactory. The effects are on pain, joint mobility and do not result in bony change.

Of 25 cases, there was amelioration after the second to third treatment in 4 cases, after the fourth treatment in 6 cases, and after the sixth treatment in 8 cases. Sometimes relief occurred unexpectedly in two weeks. Treatments occasionally needed to be repeated in a month. The permanence of the relief, however, was not determined.—*M. L. Sussman.*

Kelly, James F., Dowell, D. Arnold, Russum, B. Carl, and Colien, F. E. The practical and experimental aspects of the roentgen treatment of *Bacillus welchii* (gas gangrene) and other gas-forming infections. *Radiology*, Nov., 1938, *31*, 608–619.

The value of roentgen therapy in the treatment of gas gangrene is thoroughly established by this report. When used early and as outlined by the authors, this form of therapy approaches a specific in that it is by far the most effective measure so far employed.

It is recommended that roentgen therapy be given at the first suspicion of gas bacillus infection and to all cases in which the infection would be likely to develop. For the early cases a roentgenogram showing gas in the subcutaneous tissue will aid in establishing the diagnosis. Extensive débridement and amputation for the infection is not necessary.

The technique depends upon the location of the infection and the thickness of the part involved. Kilovoltage and filtration to insure adequate pentration are necesssary; 100 r per area is given twice daily for three to five days, depending upon the progress of the case. From the results, the authors feel justified in predicting that if treatment is begun within the first twenty-four hours of the disease, there should be 100 per cent recovery. The use of serum is not essential, in the opinion of the authors, but when used, it should be given in a conservative manner.—*J. H. Harris.*

MISCELLANEOUS

Galapeaux, E. A., and Templeton, R. D. The influence of filling the stomach on the colon motility and defecation in the dog. *Am. J. M. Sc.*, Feb., 1938. *195*, 230–233.

Holzknecht observed that mass movements developed in the colon shortly after feeding a bismuth meal. Hertz noted that this reaction also followed the sight of food but that a more effective stimulus was accomplished with food bulk in the stomach; he termed the phenomenon "gastro-colic reflex." Welch and Plant claimed that this reflex could not be excited when food was introduced by way of a gastrostomy. They considered the phenomenon a "feeding reflex." Ivy found that stimulation of the duodenum and upper jejunum caused defecation but claimed that distention of the stomach "never" produced such an effect. He believed the reflex to be "duodeno-colic."

The authors carried out several types of experiments: They recorded contractions of balloons set in tandem, through cecostomies and per anum, as effected by balloon distentions of the stomach versus stomach tube feedings of 1,100 cc. of buttermilk. The filling of the stomach with the yeast and buttermilk mixture was followed by an increase in colon activity. This began during the first fifty minutes after injection and did not reach a peak even by the close of the experiment, 200 minutes later. The trained dogs withheld actual defecation except when in the room where they ordinarily performed it, but among 32 untrained dogs, only 9 failed to show the defecation response. Gastrostomies were then performed on 3 of the untrained dogs which had shown the response. After several weeks' rest for tissue healings, the buttermilk mixture was given by way of the gastrostomy opening. Defecation followed in every instance "as quickly as when the stomach was filled by way of the esophagus." To eliminate the possibility of stimulation of the small intestine by out-pourings of the fluid from the stomach, a bag was then inserted into each

stomach and distended with 1,100 cc. of air. Defecation resulted within one minute, in every instance.—*A. A. de Lorimier.*

Boyd, Eldon M. The effect of benzedrine sulphate on the bowel and uterus. *Am. J. M. Sc.*, April, 1938, *195*, 445–448.

Benzedrine (benzyl methyl carbinamine), chemically similar to ephedrine, was introduced primarily for topical application to the mucous membranes of the nose and throat in cases of congestion. Several observers have expressed the opinion that, like epinephrine, it will effect relaxation of the gastrointestinal musculature. Others have contradicted this. The author therefore tested strips of smooth muscle of the small intestine and uterus of rabbits and guinea pigs. Such segments were placed in Locke's solution and following the Magnus technique, rhythmic contractions were recorded kymographically. After a control record of normal contractions, benzedrine sulphate ephedrine hydrochlorid and epinephrine hydrochlorid were added, using concentrations of 0.01 to 0.001 per cent. Benzedrine invariably produced a prolonged contraction of the longitudinal musculature of the small intestine and of the uterine musculature. Ephedrine produced effects which were similar to those of the benzedrine, though not as consistently, while epinephrine relaxed the smooth muscle and inhibited practically all rhythmic contractions.

These experiments were repeated after preliminary cocainization. The relaxation as produced by the epinephrine was increased but both benzedrine and ephedrine again effected stimulation—though not quite as much as before. Similar results were obtained when ergotamine was used in place of the cocaine. It therefore seemed that benzedrine did not act upon the parasympathetics, for when atropine was first applied there was no essential change in the effects of the benzedrine. The conclusions seemed to be that when used in the concentrations mentioned, at least in the case of the smooth musculature of the rabbit or the guinea pig, benzedrine acts directly, producing contraction.—*A. A. de Lorimier.*

Feller, A. Der Einfluss des Radiums und des Benzols auf das Blut und auf die blutbildenden Organe mit besonderer Berücksichtigung der Leukozyten. (The effect of radium and benzol on the blood and blood-forming organs, with special reference to the leukocytes.) *Strahlentherapie*, 1937, *60*, 393–400.

As it has been noted that the effects of radium on the blood and blood-forming organs are strikingly similar to those of benzol, experiments were made to compare the action of these two substances experimentally. The experiments were made on rats, 3 being treated with benzol and 6 irradiated with radium. The technique of the experiments is described and curves given showing the details of the results.

The changes in the total number of leukocytes and the relative proportions and the histological changes in the blood-forming organs were strikingly similar with benzol and radium. Regeneration took place much more quickly, however, after benzol than after radium. Small differences such as eosinophilia, beginning decrease in the number of neutrophiles and slighter changes in the number of erythrocytes and the percentage of hemoglobin in the rats treated with benzol seemed to indicate that there are differences in the mode of action of the two toxins. It is impossible at present, however, to say to what extent this is true and what the differences are. Nor has it yet been decided whether radium and benzol act on the leukocytes directly or only indirectly through the blood-forming organs. The terminal paralysis of the blood-forming organs may be caused primarily or secondarily by the action of leukotoxins set free from the destroyed leukocytes.—*Audrey G. Morgan.*

Gregori, A. Die biologische Wirkung der kontinuierlichen and rhythmisch unterbrochenen Röntgenbestrahlung auf die Eier von Drosophila melanogaster. (The biological action of continuous and rhythmically interrupted roentgen irradiation on the eggs of *Drosophila melanogaster*.) *Strahlentherapie*, 1937, *60*, 422–426.

Experiments were made to determine the action of roentgen irradiation with a high r/min. influx as compared with one with a lower r/min. influx and also to determine the effect of rhythmically interrupting the irradiation. The eggs of *Drosophila melanogaster* were used for the tests.

It was found that the biological action was decreased by lowering the r/min. influx with continuous irradiation. A curve is given showing the degree of decrease.

If a high r/sec. influx is used and the time of irradiation lengthened by rhythmical interruption of the irradiation with the dose remaining the same so that the r/min. influx is shortened to a third and the irradiation time thereby lengthened to three times what it was before, the degree of biological action is not the same as with a continuous irradiation but is greater; it is the same as that obtained with continuous irradiation with a high r/min. influx in a third of the time.—*Audrey G. Morgan.*

Kirchhoff, H., and Kelbing, W. Experimenteller Beitrag zum Zeitfaktorproblem. Histologische Studien am Kaninchenhoden zur Klärung des Einflusses der Protrahierung bei der Coutard-Bestrahlung. (Experimental contribution to the problem of the time factor. Histological studies of the rabbit's testicle to determine the effect of protraction in Coutard irradiation.) *Strahlentherapie*, 1937, *60*, 444–465.

The Coutard method of irradiating malignant tumors included not only an increase and fractionating of the dose but a protraction of the time brought about by decrease of the r/min. influx caused chiefly by greater focus-skin distance and heavier filtration. It is generally agreed that the fractionating of the dose has led to better results in tumor treatment, but there is some question as to the value of protracting the time. Unless this brings decided advantage it is not advisable because it increases the time and expense of irradiation and the demands made on the time of physician and personnel.

The authors had the impression from their clinical experience that little or nothing was gained by protracting the time. But they wanted experimental confirmation of this impression and so they irradiated rabbits' testicles. The testicle on the right side was given simple fractional irradiation while the left one was given protracted-fractional treatment. Careful histological studies were then made of the two testicles. The testicle on one side was of course protected while the other one was being irradiated. The testicles of several non-irradiated animals were examined for controls.

In order to get good comparisons, the conditions were made as uniform as possible. Animals 1 to 7 were irradiated with 170 kv. tube tension and 1.2 mm. copper and 1 mm. aluminum filtration, animals 8 to 14 with 180 kv. and 0.7 mm. copper and 1 mm. aluminum, filter. The number of amperes was 3 to 4. Protraction was brought about chiefly by varying the focus-skin distance which was from 20 to 125 cm. Fractional doses of 200 r measured in free air were given, at intervals of twenty-four hours.

The histological findings are described in detail and photomicrographs given. They showed that protracted-fractional irradiation did not have any greater effect than simple fractional irradiation. Nor was there any particularly greater amount of injury on the side given protracted irradiation. It is possible that in an object as sensitive to irradiation as the rabbit's testicle the injury brought about by simple fractional irradiation is so great that no greater injury could be produced by protraction under the conditions used in the experiments, or that the difference was so slight that it could not be demonstrated. But if that is true the more intense action of protracted irradiation would be so slight that it could not have much practical effect in treatment. The authors believe therefore that extreme protraction is not necessary in using the fractional method.—*Audrey G. Morgan.*

Vollmar, H., and Rajewsky, B. Mikrokinematographische Studien über die Wirkung von Röntgenstrahlen auf normale und Tumorzellen in Gewebekulturen. (Microcinematographic studies of the effect of roentgen rays on normal and tumor cells in tissue cultures.) *Strahlentherapie*, 1937, *60*, 524–540.

The authors discuss their method of making cinematographic pictures of normal and tumor cells while they are under the influence of roentgen irradiation. A roentgen tube is fixed into the microcinematographic apparatus so that the films can be taken while the tissue is being irradiated. In this way the whole process can be shown and these film protocols can be used for study and the compilation of statistical data. The apparatus is described and illustrated.

Quite definite pictures of the effect of irradiation on normal cells could be obtained. In thirty and even sixty minutes there was little or no injury, but after 120 minutes injury began and proceeded to death of the cell. The effects were not nearly so uniform on tumor cells. The films show very great differences in the sensitiveness to irradiation of these cells. The same dose does not always have the same effect in different experiments. Even with very large doses there are always some cells that are affected very little or

not at all. It was found that there was a marked difference in the inhibition of growth of the cells in the part of the tissue turned toward the roentgen tube and that turned away from it showing that the rays do have a local effect. Photomicrographs of different kinds of cells after varying periods of different strengths of irradiation are given.

These film protocols promise to be of great value in studying the effect of irradiation on cells.—*Audrey G. Morgan.*

Grebe, L. 25 Jahre Laue-Diagramm. (Twenty-fifth anniversary of the Laue diagram.) *Strahlentherapie*, 1938, *61*, 1–3.

In 1912 the diffraction of light in crystals was discovered by Laue; that is, the idea was conceived by him and the experimental work was done by W. Friedrich and P. Knipping. From a study of Barkla's investigation of the dispersion of roentgen radiation in matter and of Bravais' theory of the arrangement of atoms in crystals following a lattice-work, Laue concluded that roentgen rays must undergo diffraction in crystals. This theory was confirmed by experiments. Laue's equations were developed from extension of the relationships of a one-dimensional lattice to a three-dimensional one, and with the incidence of roentgen irradiation throughout an extensive region of the spectrum require monochromatic interference spots, the symmetry of which stands in a simple relationship to those of the irradiated crystal. The experimental arrangement with which Friedrich and Kippel demonstrated the truth of this theory is illustrated with a sketch from the original work and another illustration is given showing the images obtained on a zinc diaphragm in two orientations with reference to the crystallographic axis.

This work began a whole new chapter in roentgenology. In the first place, it made it possible to definitely determine the wave lengths of roentgen rays by means of known kinds of crystals, so that it was possible to develop a spectroscopy of roentgen rays. On the other hand, the knowledge of the wave lengths of the roentgen rays established a foundation for an understanding of the structure of crystals from the interference pictures given by the crystals.

A great deal of experimental work has been done in both these directions in the past twenty-five years. Only a hint can be given of the rich results of some of this work, such as the contributions made to the knowledge of the physics of the atom by the measurement of wave lengths, the knowledge obtained in regard to the structure of matter, creating a whole new mineralogy, the enrichment of the methods of chemical analysis which has even led to the discovery of new elements, such as hafnium, mesurium and rhenium, the development of possibilities of studying the structure of the molecule and improved knowledge of the structure of the tissues. This shows, as history has so often done, that work begun from a purely scientific and speculative point of view may be of the greatest value in practical fields of development.—*Audrey G. Morgan.*